# Technical Research Supplement to the Corn Furnace Program Feasibility Study for Wisconsin

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*The power is within you.*

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## Technical Research Supplement

More details regarding the research on the feasibility of corn-burning furnaces in Wisconsin are presented in this technical report which is a supplement to Corn Furnace Feasibility Study. We present the results in categories useful to future program design:

- Corn-burning options
- Benefits and disadvantages of burning corn
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- Corn Furnace sales
- Corn markets, futures, prices and costs
- Program design and benefit-cost analyses
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### Corn Burning Options for Homes

Corn burning is not common and has not been since the Great Depression.
Corn burning stoves have been available since the early 1990s, and more recently some manufacturers of stoves have developed corn-burning furnaces and boilers. Also, entrepreneurs increasingly have been manufacturing corn-burning furnaces.

This feasibility study focuses on furnaces but also assesses corn-burning stoves. It is notable that manufacturers are developing stoves (and furnaces) that can burn more than one fuel (a.k.a. multi-fuel and biomass). Currently furnaces and stoves that burn corn and wood pellets interchangeably or mixed dominate the market. Other biomass fuels are being developed at an increasing rate.

***Types of Corn-burning Systems***

In this study we use the word “furnace” to include boilers to simplify the text. These devices, unlike stoves are designed to distribute the heat throughout the home through either air or water exchange to each of the heated rooms. The “furnace” can be located either inside the house or outside. In most cases if the unit is located outside, the appliance uses water to deliver the heat from the burner box. For systems installed inside the home the choice of technology is driven by the home’s existing heating system. For new homes of course the choice is more flexible.

*Outside corn boiler* - This unit delivers heated water to either a boiler system in the home or to a heat exchanger that is installed in the supply plenum in the existing furnace.

This is shown in the pictures above. The corn-boiler sits outside the house and hot water pipes are buried (and insulated) below the ground – penetrating the basement wall. The heated water piping goes to the heat exchanger that can be seen at the top of the supply plenum in the picture on the right.[1]

One of the limitations of this technology is its outdoor presence. Increasingly cities are zoning such that these "unsightly" appliances are not allowed. Thus they are often limited in use to more rural locations. This rezoning is primarily driven by outdoor wood burning boilers which create local pollution affecting nearby neighbors. Two other disadvantages of this technology are that it typically is more costly than the indoor units on the market and it has lower overall efficiency. The lower efficiency is due to the appliance being outside and the need to pipe the heat to the furnace or boiler system in the house.

*Inside Corn Burner* - there are two alternatives for inside corn-burning appliances. The first is a corn-burning boiler. This unit is typically connected to the existing heating system hot water piping. It circulates hot water throughout the house the same as the fossil-fuel boiler would. The other system is a hot air furnace that heats air circulated through ductwork. This corn burner is ducted to the same supply and return systems that the fossil fuel furnace uses.

1 The above pictures are from the www.thecornburner.com website.

Following pictures show a boiler and a hot air furnace.

*Corn Burning Stove* - a modern corn (or pellet, or multi-fuel) stove is set up in one room and has a fan which circulates room air across a heat exchanger having the combustion heat on the other side. While using a stove limits how much of the heat can be circulated to other rooms, the cost is significantly lower than that of a furnace. [2]

By running the existing fossil-fuel furnace blower, the heat can be better circulated to other rooms in the home. This becomes an even better option if the existing furnace has an ECM furnace fan motor run at low speed – reducing the electricity cost for moving the air.

At present most stoves and furnaces being purchased to offset fossil-fuel heating burn wood pellets. These operate the same as their corn counterpart and in many cases they are the same appliance (multi-fuel). The environmental benefits of corn and pellet burning are likely similar. Because pellets have been a viable fuel for more than 20 years, there are more equipment options than available for corn burning. No picture is provided because a pellet furnace looks just like a corn furnace.

2 Stove picture from http://www.lennoxhearthproducts.com/selectionguide/

## Benefits and Disadvantages of Burning Corn

There are a variety of benefits and costs related to burning corn to heat the home. Some of these are economic while others are social or emotional.

### *Potential Benefits of Burning Corn for Home Heating*

1. Corn-burning appliances have lower emissions than most alternatives – The most promising emission reduction is that of $CO_2$, the dominant greenhouse gas. Because the corn being burned absorbs $CO_2$ during its recent growing, burning corn results in less $CO_2$ being emitted to the atmosphere – reducing the impact on global warming.
2. Corn-burning reduces the U.S. dependency on foreign oil and all the security issues related to this dependency.
3. Corn-burning keeps money in the local economy – money is not sent out of state.
4. Buying corn from the local farmer provides him/her with a better living – The farmer can charge the homeowner a higher price than he can get from the market.
5. Corn-burning can result in lower bills for heating the home in some cases.

### *Disadvantages of Burning Corn*

Homeowners who are considering purchasing a corn-burning furnace should weigh the following disadvantages of this decision.

1. Corn-burning requires more work. The fossil-fuel furnace heats with no effort. Using a corn-burning furnace requires added effort to buy and clean the corn, dust the house, and operate and clean the furnace.
2. If the homeowner does not purchase corn wisely, it may cost more than using fossil-fuels.
3. The corn-burning furnace and its accessories are expensive and this purchase has a long payback period for some situations.

## Furnace and Stove System Costs

The cost of a corn furnace system varies, as for any type of appliance. There are outdoor corn-burning stoves that can cost more than $10,000. While these might be marketed as applicable to residences, it is likely they cannot compete for this market. The cost of corn-burning stoves is significantly lower than that of furnaces. This is due both to the lower appliance costs and installation cost.

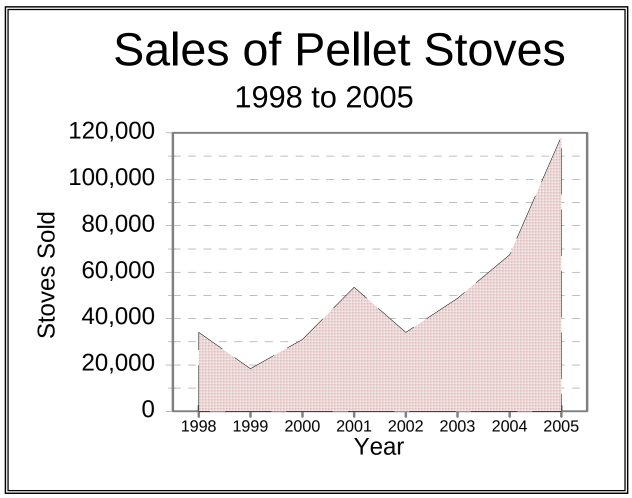
We have found a reasonable range of biomass furnace costs (installed) to be about $4,000 to $6,000. Using what little data available we estimate the average installed cost of an affordable biomass furnace to be about $5,000. Depending on the handling cost of the fuel, the accessories needed to operate the furnace are between $100 and $555. The following table summarizes our capital investment estimates for burning corn and wood pellets. Similarly, we estimate the installed cost of a stove to be about $3,200.

| Investment Costs for Installing Corn Furnaces and Stoves in Homes | | | | | | |
|---|---|---|---|---|---|---|
| | Furnace System Costs | | | Stove System Costs | | |
| | Pellet | Corn - Basic | Corn - Value | Pellet | Corn - Basic | Corn - Value |
| Furnace Cost | $3,500 | $3,500 | $3,500 | $2,200 | $2,200 | $2,200 |
| Installation Cost | $1,000 | $1,000 | $1,000 | $500 | $500 | $500 |
| Accessories | $100 | $555 | $120 | $100 | $555 | $120 |
| Total Cost | $4,600 | $5,055 | $4,620 | $2,800 | $3,255 | $2,820 |

The "Corn-Basic" columns refer to the scenario where the corn is purchased, from a local farmer, it needs to be handled and cleaned more than the other fuel options.[3] Both the pellet and "Corn-Value" fuels typically come in 40# or 50# bags and are ready to be dumped into the biomass furnace hopper with little handling.

## Corn-Furnace Sales

Corn burning was popular during the early 1900s – especially during the Great Depression of the 1930s because corn was highly available and inexpensive in rural areas. However, in those days, the whole stock of the corn harvest was burned in stoves – kernels, stover, and cob. In recent years the cost of fossil fuels used to heat homes has slowly risen to a level where farmers who grow or have access to corn have started to burn corn kernels in stoves and most recently in furnaces and boilers. Only in the last few years has the cost of these fossil fuels increased sharply enough to inspire some entrepreneurs in the stove industries to develop corn furnaces that are reliable.




During the winter of 2005-2006 the demand for corn-burning stoves and furnaces increased sharply. The corn-burning manufacturing companies were not ready for the demand. During the 2006-2007 winter they are busy filling back orders from 2005-2006.

### *Corn Stove and Furnace Sales*

While corn burning stoves had an early life during the depression of the 1930s, they largely disappeared as inexpensive fossil fuels were made available to most homes in the U.S. After the depression, where homeowners were interested in using alternative-energy stoves or furnaces in their homes, the fuel of choice was cordwood. Before corn-burning again started to become popular, wood-pellet stoves became the fuel of choice to replace cordwood burning in stoves. These pellet stoves started to be sold in earnest during the 1980s. In the 1990s some stove manufacturers started complementing their wood and pellet stove lines with a few corn stoves. By the turn of this century, several manufacturers were producing corn-burning furnaces.

3 Corn-Basic and Corn-Value are defined elsewhere in this report - but the primary advantages of "Value" Corn are its higher energy density, cleanliness and ease of handling. This comes at a significantly higher price, however.

Recent data showing sales of pellet stoves are available from the Hearth, Patio, and Barbeque Association (HPBA). Since 1998 sales of pellet stoves and furnaces has grown from 34,000 to over 118,000 units per year in 2005. From data available and assumptions we estimate that over 600,000 stoves have been sold in the U.S. since the early 1980s. In addition, according to the Pellet Fuels Institute wood pellet manufacturers expect they will have increased production by 35% for the 2006-2007 winter season.

Though there are some dips, it is clear that the sales of wood pellet stoves have been increasing in the last eight years. And the significant increase, nearly a doubling, in the last year has significance to the sales of corn furnaces.

The history of sales of corn appliances is short and not tracked. One news article in 2006 says that "an industry expert" suggested that 30,000 corn stoves and furnaces were sold during the winter of 2005/2006 and half as many were sold the year before. Another article suggests that the number of units sold has doubled each year for the past five years. And the president of American Energy Systems, a leader in the sales of biomass stoves suggests that there were about 65,000 corn stoves sold in the US last year.

Analyzing the weak information available from these sources and using the assumption that sales of corn-burning appliances have doubled each year since 1990 to sales of 30,000 last year, we estimate that there have been about 60,000 corn-burning appliances sold in the U.S through the spring of 2006. As discussed elsewhere, we estimate that more than 80% of these appliances were stoves. Thus, this approach suggests that up to 12,000 corn furnaces have been sold in the U.S. If we assume that equal numbers of furnaces have been sold in six Midwest states from Michigan to Illinois to Minnesota, it is likely that no more than 2,000 corn furnaces and 8,000 corn stoves have been sold in Wisconsin.

Another approach we took was to ask the manufacturers we spoke with how many furnaces they sold in the last few years in Wisconsin. Only one offered clear sales in Wisconsin, and this was off the top of his head. We also asked the Wisconsin dealers we spoke how many furnaces they sold. A couple of the dealers offered guesses of sales of furnaces. Some could tell us how many corn burning units they sold but could not break out furnaces from the figure. More often they said they could not share that information. From the sales data we accumulated from dealers there are likely to be a total of 1,000 to 2,000 corn-burning furnaces in Wisconsin as of December 2006. And there are likely 4,000 to 8,000 stoves.

From information we collected from dealers we expect that possibly 40% of all corn furnaces in Wisconsin were sold last year and another 40% sold this year. However, many of this year's sales are back orders from last year. The sharp increase last year was due to the spiking fossil-fuel costs. The manufacturers were not geared up for that demand. This year "new orders" are down significantly. Also, it appears that the sales of corn-burning stoves have been spread out over more years than furnaces. More, the manufactures, and new entrants, are gearing up for greater sales and improving their stoves and furnaces for burning not only corn but multiple biomass fuels.

We identified 23 manufacturers of corn-burning (or multi-fuel) furnaces. Most of them are small operations and most of them added corn-burning furnaces onto their line of stoves when they started seeing more corn burning. The implication here is that this is a growth industry. Five of these manufacturers are making the same product. Four companies of these companies are producing a furnace and boiler based on a design developed by Big M Manufacturing in Illinois. These four companies have a licensee arrangement with Big M for the design.

In summary, we estimate that there are likely between 1,000 and 2,000 corn-burning furnaces and between 4,000 and 8,000 corn-burning stoves in Wisconsin. However, because there is no industry tracking of corn-burning-appliance sales, these estimates carry a low confidence level. In November 2005 the Energy Center of Wisconsin completed what is referred to as the "Potential Study." In this study it suggests that about 90,000 natural and LP gas furnaces are sold in Wisconsin each year. The total number of corn-burning furnaces installed in Wisconsin is likely less than 5% or the annual sales of gas furnaces.[4]

## Corn Markets, Futures, Prices and Costs

### *Uses of Corn*

Corn has been a staple in diets around the world for hundreds of years. Burning corn for habitat heating is not a new idea. However, corn markets are changing faster now than ever because of the evolution of use of corn.

Few persons realize the breadth of end-uses of corn. We all see the news about converting corn to ethanol because of concerns with dwindling world oil supplies. In addition there are hundreds of food products produced by corn.

[4] Energy Efficiency and Customer-Sited Renewable Energy: Achievable Potential in Wisconsin 2006-2015, ECW report 236-1, www.ecw.org/resources/publications

But not all corn is created equal. Other then the food quality corn, there are other types of corn grown for other purposes. The most relevant to this feasibility study is “feed-stock” corn. This is the corn used to feed livestock – cows, pigs, chickens, etc. This is the grade of corn being diverted to ethanol and burning in homes. While about 20% of U.S. produced corn is exported, it is not sent to second-world countries for directly feeding the poor. There is also a “seed corn” which is sold back to farmers for seeding their fields.

The corn used for burning is labeled Grade #2 – “feed corn” or “yellow corn.” This corn is removed from the field with a “combine.” This large machine is driven through the corn fields “scoping” the ears of corn. This corn flows through the combine separating the corn kernels from the cob and the stover, and air-lifting the kernels to a storage hopper at the top. The cob and stover are then redistributed on the field for cover and eventual fertilization.

The hopper in the combine often has significant “contaminants” mixed with the corn. We define contaminants in the context of whether these components degrade the burning value of the corn sold for burning. Un-cleaned corn has several typical contaminants such as fines (small parts of stover and cob) and beeswings (small slivers of skin from the lower part of the kernel). These contaminants, if not removed, can foul up some augers and also will result in more ash and clinkers. If the corn is not cleaned, the homeowner must purchase accessories to clean it. If the corn is cleaned by the supplier, the cost of the corn will be greater.

***Corn Markets and Futures***

Corn can be sold to local users or placed on the market where it is traded through the Chicago Board of Trade (CBoT). Regardless of the sales channel, the price is driven by the global-trade market. The farmer is inclined to sell corn to whomever offers the highest price.

The most concise way to show how the global market impacts the cost of corn to the homeowner is by discussing why the cost of corn increased significantly last year from the previous year (and historic trends). Homeowners we have talked with paid between $1.85 and $2.35 per bushel for the 2005/2006 heating season. Early in this heating season (2006/2007) they were paying between $3.20 and 3.60 per bushel.[5]

We define the “price of corn” as the CBoT price per bushel. The historic cost of corn substantially has been between $2.00 and $2.50 per bushel. There have, however, been very short-term spikes in the price of corn in past years – the last of which was on July 12, 1996 when it peaked at about $5.55 per bushel. This year the price of corn peaked in January (2007) at just above $4.00 per bushel.

[5] The heating season before last (2004/2005) some were paying between $1.60 and $1.95 per bushel.

There are, of course, a variety of theories why the price of corn spiked this year. The most common belief is that the spike is due to the accelerated growth of ethanol plants. While this may play a role, there are other factors that contribute to spikes. One key factor in the price of corn is speculation by the market speculators. If the speculators think the cost of corn will jump, they will try to get in at a lower cost than their anticipated price. This activity drives up, or down, the cost of corn in some years. However, another important determinant of prices is supply and demand. According to our contact at the Wisconsin Corn Growers Association, the spike in cost of corn this year is due to the extremely bad wheat crop in Australia last year. Corn and other crops are used to feed the cattle when wheat production is low. He suggests that we exported 2.5 billion bushels of corn last year compared to the normal 1.5 billion bushels, in part because of Australia's wheat shortage. This resulted in an imbalance of corn supply vs. demand causing the price to jump. Australia is the second largest exporter of wheat - after the U.S.

While there is variation in beliefs about what the causes of rising corn prices are, there is consistency in the belief among most interviewed that this crop will likely level out at a new long-term average in the future. The most common price believed is in the order of $2.50 per bushel. That is, while the price of corn has spiked to about $4.00 this year, the market forces will drive it back toward near the previous long term price. Some futures markets, however, suggest higher prices.

One of the advantages of the new multi-fuel furnaces and stoves is that the homeowner will be able to choose the fuel to burn - to minimize his/her heating costs. And this competition will likely put downward pressure on the price of corn for burning.

***Corn Cost to Homeowner***

The price of corn discussed above is higher than that which the farmer is paid for the corn. There are costs to bring the corn to market: the mill or coop handling costs, and the cost of transportation to a surrogate Chicago distance. This latter cost is called the "basis" and is currently about $0.30 per bushel from central Wisconsin. An example: if the CBoT price is $3.00 per bushel the price at the grain mill or coop will be about $2.70 per bushel. If the mill or coop charges $0.30 per bushel to dry and handle the corn then they will offer the local farmer $2.40 per bushel.

A low end scenario is also instructive. When the price for corn was $2.20 last year, the price less basis was $1.90 per bushel and the farmer would get about $1.60 per bushel. However, the cost to produce corn in Wisconsin is about $1.80 to $2.00 per bushel. So, often the farmer is not paid the full cost to produce corn. When this typical scenario exists the government provides a subsidy up to $0.60 per bushel. When the cost of corn is higher the government subsidy is lower. As one farmer we spoke with said, "we would rather get a reasonable price for corn than receive government welfare."

The cost for corn that the homeowner will see is likely to be more than what the farmer can get at the mill or coop. In general it would not make sense for the farmer to charge a homeowner less than he can get at the mill or coop. However, the mill or coop is typically going to charge more to the homeowner than it can get from selling the corn on the market. Thus, there is room for the farmer to sell the corn to homeowners above what the mill or coop will pay him (the farmer) but less for what the homeowner would pay that mill or coop. For the first scenario above where the farmer is paid $2.40 per bushel, the homeowner is likely to be charged above the market price of $3.00 at the mill or coop. So, for example, if the farmer charges the homeowner, say, $2.70 per bushel, the homeowner can save more than $0.30 per bushel while the farmer makes and extra $0.30 per bushel.

A quote from a farmer is illustrative "I am charging more than I would get at the elevator, I charge $2.50 a bushel versus a $1.70 to a $1.90 at the local elevator," says Hudson. "I'm making more a bushel, but I'm not selling a big volume," he says. "I think it will increase, I really do, especially if the fossil fuel price stays up."

The largest manufacturer of corn-burning furnaces and stoves states that a large percentage of his customers grow their own corn. This allows them to save significantly on their fossil-fuel bills because their effective cost of corn is very low. He suggests that they perceive their cost of the corn at the cost to grow it – about $2.00 per bushel in Wisconsin. While we do not use this, sub-market cost in our analysis, it is useful for discussion regarding program design.

In one analysis we assume the average homeowner will be purchasing corn from farmers, or at the mill or coop. One task of a program that might be developed could be to facilitate relationships between homeowners and local farmers to purchase corn more affordably. This will have the market impact of also lowering the cost that the mills and coops charge homeowners to get some of that market.

***Homeowners' Extra Work – a Non-Financial Cost***

One attribute of corn-burning that is not included in either the customer or program cost/benefit analysis is the extra work required to burn corn instead of just adjusting the thermostat.

One of the homeowners who we learned from has a video on the internet showing the cleaning process for his "A-maiz-ing Heat" boiler. In that video he confides, "You gotta really want to do it (cleaning labor) because if you are not willing to do it, these (corn boilers/furnaces) are not for you. His neighbor has a Traeger corn furnace and shows how he cleans it on another video on the same site page.[6]

[6] http://www.iburncorn.com/videos/cleaningAndChange.cfm

One of the dealers we spoke with suggests that there is a very limited market for corn-burning furnaces because the owner has to be mechanically inclined and can appreciate the maintenance they take. He says he "wouldn't sell one of these to his mother or yours." Indeed, he tries to steer customers who come in asking about corn-burning furnaces to multi-fuel stoves, or if they insist on a furnace, to a pellet furnace.

There are differences in opinion among the variety or market players we met and spoke with about the amount of time it takes to keep the corn furnaces operating efficiently. From these opinions we conclude that one can expect to have to do the following chores:

- Clean and move corn to the hopper daily – up to15 minutes
- Remove clinkers and ash in the pot almost daily – up to 15 minutes
- Clean the ash bin out every 3 days to a week – up to 15 minutes
- Clean out the burn pot up to four times per year – up to two hours

The requirements for keeping the corn furnace running efficiently depend on the type of unit and the manufacturer.

In addition extra effort is required to pick up the corn and prepare it for storage at the home. These requirements for this vary significantly based on the homeowner's particular situation and we do not have enough information to suggest an average time commitment for this work.

While we do not dwell on the use of corn stoves, it should be noted that the effort to burn corn in a stove typically is significantly less than in a furnace. However, this leads to another barrier to burning corn compared to using fossil fuels.

No matter how clean the purchased corn is, the homeowner will have a dustier home – at least in the areas where the corn and ash are handled. This suggests an advantage of the furnace over the stove. The dust caused by the furnace will be confined mostly to where the corn is stored (outside, garage, basement) and where it is burned (basement for furnace). Because the stove is likely to be located in a common living space – such as the living room – the living space will likely be dustier.

The following table shows our best-estimate breakdown of the accessories needed for burning each fuel type discussed earlier.

| **Costs of Accessories required to burn biomass** | | | |
|---|---|---|---|
| | Pellets | Corn - Basic | Corn - Value |
| Auto maintenance | $100 | $100 | $100 |
| Shop-Vac | | $100 | |
| Tubs or Bags | | $35 | |
| Shur-Kleen corn cleaner | | $300 | |
| Igniting supplies | | $20 | $20 |
| Total Accessory Cost = | $100 | $555 | $120 |

### ***Reasons for Burning Corn***

There are a variety of reasons that homeowners purchase corn-burning appliances. These include:

- Desire to reduce home heating costs
- Interest in lessening their environmental impact – some cited global warming
- Desire to improve the local economy
- Concern for oil dependency and it relationship to national security

As discussed in the upcoming Benefit/Cost Analysis section, there are a limited set of circumstances where burning corn makes economic sense – even before considering the added work.  Thus, it is likely that many of the persons choosing this heating option will do so for one or more of the reasons above. We asked our interviewees why they or others burn corn. Most initially stated that it was to save money and lessen environmental impact.

Where we suggested to manufacturers and dealers that there are not likely significant savings at current corn and fossil fuel costs they pointed out all four of the reasons stated above. We note that the drastic spike in corn furnace and stove orders last year and the plummeting orders this year supports suggests economics is a dominant factor in homeowners deciding to purchase these appliances.

## Program Design Options

This section discusses several potential “corn-furnace” program designs. The designs are based on the current state of the “corn-burning-in-homes” industry. The current state of the industry must set the framework within which a program is designed. The final design of a program to facilitate greater penetration of corn-burning furnaces will also depend on the results of benefit/cost analysis of the potential designs considered.

The benefit/cost analysis is done using DSMore, modeling software used by the Focus on Energy implementation team to assess the benefit-cost of various program opportunities. The inputs are quantified from the research conducted for this feasibility study.

### ***State of the Industry***

There is currently a small market developing in this industry - without influence from a public benefits facilitation program. There are interactive market attributes that must be considered in the design of a program:

1. Consumer Attitudes
2. Cost of Corn
3. Home Vintage
4. Efficiency of Conventional and Corn Furnaces

We discuss each of these toward having an understanding of the benefit/cost analysis and related program designs. The current, and future, actual market is much more complex and is discussed elsewhere.

*Consumer Attitudes*

We identified two current consumer attitudes toward burning corn to heat the home. These are the "Cost Conscious" perspective and the "Socially Conscious" perspective. These two decision making attitudes are not exclusive but may have different initial drivers for investigating corn burning. These market players are manifest in the current market as 1) those who will accept the extra effort to burn corn if the “cost” allows them to save money, and 2) those who will burn corn even when it does not save them money over their standard fuel because they derive “value” from societal benefits such as supporting the local economy and/or environmental impact reduction. The customers who have a “value” or “socially conscious” perspective are likely willing to pay more for corn - accepting a longer payback from installing a corn-burning furnace.

*Cost of Corn*

There are two channels for buying corn to burn in a furnace. Some local farmers will sell to homeowners from their farms at a price above production cost or at least above what is offered them by the local coop or mill. In the December of 2006 this was about $2.75 to $3.00 per bushel - and typically bought by the bushel by homeowners. At the same time, some homeowners are buying corn in the 40# bag from coops, mills, and retail outlets such as Farm & Fleet and Menards for about $4.00 to $4.50 per bag. This dichotomy illustrates a market imperfection. The equivalent price of a 40# bag of corn at $4.00 is $5.60 per bushel - about twice the cost of buying from the farmer directly.

There is a difference in the quality of the corn at these two prices. Typically the corn bought from the farmer requires some cleaning to remove fines, bee’s wings, and split kernels. Also, this corn is likely to have been dried to about 15% moisture. This customer has to bring containers or bags for the farmer to put the corn in. On the other hand, the corn in the bags is likely to be cleaner, dryer (12%) and in easy-to-transport 40# bags. This latter supply has “value added” to the corn in that the customer can dump the corn right into the burner hopper without having to clean it, and in that this corn has more energy per bushel. And there will be less corn dust in the garage and/or home.

We identify these two scenarios by the sub-names “Basic” corn heating” and “Value” corn heating.

*Home Vintage*

It is useful to look at the benefit/cost to customers who live in efficient “new” homes and older “existing” homes. The energy requirements for a new home are at least 30% lower than the typical existing home. We address these home stocks in the benefit cost analysis. In addition, nearly 90% of new homes have 90%+ efficient condensing furnaces – we analyze for both atmospheric and condensing furnaces.

*Efficiency of Conventional and Corn Furnaces*

The standard furnace in the consumer’s home might be a less efficient atmospheric unit or a more efficient condensing unit. We assign efficiencies of 80% for the atmospheric furnace and 92% for the condensing furnace for the analysis.

The efficiencies of biomass burning appliances have been increasing in the past few years due to improved engineering. This increase is facilitated due to the high excess air provided by a combustion blower resulting in more complete combustion – which also results in lower emissions. The higher efficiency is evidenced by the use of double walled direct vent pipe and its low discharge temperatures for some units. A report from OMNI Technologies in late 2000 suggested efficiencies of newer pellet stoves with direct venting are “likely” in the order of 78%. Improved auger/stirrer technologies likely increase efficiencies above this level. We have seen estimates of efficiencies of corn-burning furnaces between 75% and 87%. For our analyses, we assume a furnace efficiency of 80%.[7]

*Program Design Scenarios*

As with any efficiency or renewable energy program, there are a variety of ways to design a program. We look at four, related, possible program designs for a corn-burning-furnace program:

1. Awareness (and Education) Only
2. Awareness and Rebate
3. Awareness Complemented with Infrastructure Support
4. Awareness and Rebate Complemented with Infrastructure Support

Each option is outlined below.

*Awareness and Education Only* - There is already a nascent infrastructure developing around corn burning in Wisconsin. This is primarily driven by the high cost of fossil fuels (Natural and LP Gas, oil, and electricity) and competition in the corn market.

It is possible to design a program based on only providing information about the corn-burning option to homeowners. The dominant opinion of the dealers we have spoken with is that Focus should spend its money on education, if it chooses to get involved. Most do not believe that a small rebate will drive the decision for their potential customer to purchase the expensive furnace (about $4,600 installed). In addition to developing brochures and other marketing materials, Focus can provide unbiased technical information on its website - information that homeowners will need to make the right decision. This might include materials and a website to help Wisconsin homeowners easily decide whether burning corn is *a good option for them*.

This type of program is easy to administer and inexpensive. However, it may have higher free ridership than other options and tracking results will be difficult.

The estimated cost of providing this type of program would be about $55,000 for 1,000 participants and an estimated 50% free ridership. The estimated cost brake-down is shown in the table below and, accounting for free ridership is $92 per customer.

[7] We have seen one measured efficiency for a corn-burning stove of about 87% - another possible advantage of stoves.

| Cost component | Cost |
|---|---|
| Variable Admin | $5,000 |
| Fixed Admin | $50,000 |
| B/C Analysis Total = | $55,000 |
| Incentive | $0,000 |

The Fixed Administration cost is for marketing materials and website development and management. The Variable Administration shown is to try to track program impacts through dealers at an assumed five dollars per sale to provide sales data in the first year until we can show them that the program is increasing their sales.

*Awareness and Rebate* - A couple of dealers and manufacturers suggested that providing an incentive would increase the number of corn-burning furnaces installed in Wisconsin. The rebate would also help the program to better: track sales of corn furnaces, estimate savings, and perform internal evaluation of the program including estimating of free ridership.

Most suggested that providing a small rebate (below $300) would not have much effect. A reasonable rebate is thought to be 10% to 20% of the installed cost. We suggest that if an incentive is to be included initially, it be limited to about 10% of the cost, or $500.[8]

The estimated cost of providing this type of program would be $60,500 for 1,500 participants and an estimated 50% free ridership. The cost brake-down is shown in the table below and, accounting for free ridership, is $58 per customer, not including the cost of rebates.

| Cost component | Cost |
|---|---|
| Variable Admin | $10,500 |
| Fixed Admin | $50,000 |
| B/C Analysis Total = | $60,500 |
| Incentive | $750,000 |

The Variable Administration cost is the handling cost for 1,500 rebates. The Fixed Administration cost is for marketing materials and website development and management. The incentive shown is $500 per participant for 1,500 participants.

*Awareness and Support* - Focus can, in addition to building awareness, provide infrastructure support – without offering a financial incentive. The added component here would be to help connect prospective homeowners with reliable reasonable-cost corn. This would not only require setting up a database of places that can sell corn but also enlist farmers throughout the state who are willing to sell corn directly to burners.

[8] The federal 2005 Energy Plan program provides for a tax credit of 25%, (max of $3,000) for biomass burning stoves. However, this has not yet been funded. Perhaps the Focus program would provide a rebate until the government incentive program is funded.

This would require having a dedicated program manager to find and educate farmers about the benefits of selling corn to this new market for them and ensuring that the dealers have a list that they can share with their customers. The manager can also design a tool for assessing costs and benefits and paybacks for burning corn.

The free ridership would likely be lower and the number of homes burning corn would be greater than an information only program. This is because some prospects who wouldn't invest much time are likely to accept the option if they have quick, reliable information and a nearby source of reasonable cost corn. However, this program is more expensive to administer than an information only program.

This program may allow better tracking of results and quantifying of free ridership by building relationships with the dealers.

The estimated cost of providing this type of program would be $107,500 for 1,500 participants and an estimated 40% free ridership. The cost brake-down is shown in the table below and, accounting for free ridership is $102 per customer.

| Cost component | Cost |
|---|---|
| Variable Admin | $7,500 |
| Fixed Admin | $100,000 |
| B/C Analysis Total = | $107,500 |
| Incentive | $0,000 |

The Fixed Administration cost is for marketing materials and website development and management, and cost of a program manager for a year. The Variable Administration shown is to try to track program impacts through dealers at five dollars per sale to provide sales data in the first year until we can show them that the program is increasing their sales.

<u>Awareness, Support, and Rebate</u> - In addition to providing information and supporting the growing infrastructure, a Focus program might provide a rebate. The rebate would also help the program to better: track sales of corn furnaces, estimate savings, and perform internal evaluation of the program including estimating of free ridership.

The estimated cost of providing this type of program would be $114,000 for 2,000 participants and an estimated 40% free ridership. The cost brake-down is shown in the table below and, accounting for free ridership is $71 per customer.

| Cost component | Cost |
|---|---|
| Variable Admin | $14,000 |
| Fixed Admin | $100,000 |
| B/C Analysis Total = | $114,000 |
| Incentive | $1,000,000 |

The Variable Administration cost is the handling cost for 2,000 rebates. The Fixed Administration cost is for marketing materials and website development and management, and cost of a program manager for a year. The incentive shown is $500 per participant for 2,000 participants.

## Benefit/Cost Analyses

The Focus on Energy implementation team uses a software modeling tool called DSMore to calculate benefit-cost ratios for program models. Results for the scenarios described above are outlined below.

### *Benefit/Cost Inputs*

Each of the parameters is discussed and the input values are identified below. The results of the analyses are also provided.

The inputs required to perform the B/C analyses include:

a. Energy Savings
b. Energy Rates
c. Energy Cost Savings
d. Technology Lifetime
e. Incremental Cost to Install Technology
f. Program Costs, Participation, and Free Ridership
g. Participant Payback Periods

*Energy Savings*

Burning corn in a furnace decreases the amount of fossil fuels that homeowners need to heat their homes. Burning corn may also have an impact on the electrical energy used in the home. Also, dealers we spoke with typically have not sold many corn burning appliances to homeowners who were displacing wood, though they have sold a few. Thus, most systems will likely result in gas savings.

While a condensing furnace is installed in most new homes, there are many existing homes that still have atmospheric furnaces installed. Thus we compare energy savings for homes with each of these types of furnaces. Also, new homes have a lower home heating index than the average existing home. So we expand our analysis matrix by analyzing energy savings for each of these scenarios.

*Gas Savings* – We have calculated the heating energy required to heat model homes for both existing home markets and new home markets. This was done by working with Greg Nahn, Program Manager for Focus on Energy's Wisconsin ENERGY STAR Homes Program. Greg modified a scenario for two actual new homes that participated in the Focus Wisconsin ENERGY STAR Homes program. One was ranch style and the other a two-story home.

Furnace Gas Savings - These analyses show that a 3,000 ft2 code-based new home with a 92% efficient furnace has an annual energy use of 650 therms/year. This same new home with an 80% efficient furnace (which is less common) would consume 747 therms/year.

We also developed typical energy use for an older, inefficient 2,000 ft2 existing home based on information from the Characterization Study performed by the Energy Center of Wisconsin in November 2000. According to this study an average existing home uses about 50% more heating energy than the average new home modeled. Based on this we estimate the energy use for an existing home for this study. For an existing home with a 92% efficient furnace we estimate purchased heating gas of 975 therms per year. And for the same house with an 80% efficient furnace the purchased gas is about 1,121 therms per year.

The numbers just stated are the annual natural gas heating requirements of home in which a corn-burning furnace might be installed. The savings from installing that corn-burning furnace will be less than these.

Our research provided us with some insights into how corn-burning furnaces are installed and used in many homes. It is a rare situation where a fossil fuel furnace will be removed when the homeowner decides to burn corn. Only one corn-furnace dealer we spoke with could identify situations where the homeowner did not keep their fossil fuel furnace when installing the corn furnace. This dealer, who has been selling corn-furnaces in Iowa for over six years, said that in that time he has sold about 300 corn-burning heaters. He could recall only three or four situations where the homeowner is heating only with corn so this is 1% or less of his sales.

We also inquired about use of the fossil fuel furnace with homeowners we spoke with who have a corn-burning furnace installed. First, when we asked homeowners if they would have a corn-burning furnace w/o their fossil fuel furnace, all said they would not remove or be without this furnace. It is valuable to them as both a backup when there are problems with the corn furnace and as a backup if they cannot tend to the corn furnace.

So we assume that the fossil fuel furnace will be left in service when program participants install the corn furnace. Based on discussions with and information from owners of corn furnaces, we estimate that the corn furnace will displace 80% of the gas requirements to heat the home. This includes the situation where one older homeowner said that he was now keeping the house warmer because it was more affordable.

The annual estimates are shown in the table below.

| Scenario – <u>For Furnaces</u> | Gas Use (Therms) | Gas Savings (Therms) | Electric Savings* (kWh) |
|---|---|---|---|
| Existing Home (80% Furnace) | 1,121 | 896 | -90 |
| Existing Home (92% Furnace) | 974 | 780 | -78 |
| New Home (80% Furnace) | 747 | 598 | -60 |
| New Home (92% Furnace) | 650 | 520 | -52 |

* See the section below for explanation for electric (negative) savings.

Stove Gas Savings – Stoves installations in a central room such as the living room are more common than furnace installations. Some of the manufacturers and dealers we spoke to suggested that stoves often save more energy than furnaces because the homeowner learns to let distant bedrooms go colder as long as they have a warm common area.[9]

We assume that stoves will not typically save more than furnaces in our analysis. Instead we assume that stoves will save 70% of the gas that the house would have otherwise have needed for heating – compared to 80% for furnaces. Modeling the energy and use for the same homes as we used for the furnace, we find less savings from installing a stove in lieu of a furnace.

The savings from installing a stove in the home are shown in the next table.

| Scenario – <u>For Stoves</u> | Gas Use (Therms) | Gas Savings (Therms) | Electric Savings* (kWh) |
|---|---|---|---|
| Existing Home (80% Furnace) | 1,121 | 784 | 471 |
| Existing Home (80% Furnace) | 974 | 682 | 409 |
| New Home (80% Furnace) | 747 | 523 | 314 |
| New Home (92% Furnace) | 650 | 455 | 273 |

* See the section below for explanation for electric savings.

[9] See the discussion about zoning later in the report.

Electricity Savings - Fossil-fuel and corn-burning appliances both need electricity to operate. This power is needed to operate not only the control circuitry but the blower (and combustion fan for the condensing furnace). Given the low saturation of sales of furnaces with electrically commutated motors (ECM), we can safely assume that the horsepower of the blower motor is about the same for both the fossil-fuel and corn-burning furnace (~ ½ hp). Another finding discussed in the Characterization Study mentioned earlier is that for non-ECM furnaces the annual electricity use of the furnace is about 1 kWh per heating therm over the heating season. Thus for the four scenarios suggested in the table above we can expect annual electricity use of the furnace to be about 747, 650, 1,121, and 974 kWh/year respectively.

Another finding from our investigation into the use of corn burning furnaces is that one out of the three of the homes visited had the corn-burning furnace installed in series with the fossil fuel furnace. In this arrangement, the fossil-fuel furnace's blower must be operated whenever the corn furnace is operating. This is needed to overcome the increased static pressure of the serial system.

We have spoken to a couple of manufactures who suggest that the series installation is not common. So we assume that one in ten furnaces will be installed in series. Thus, the average use of electricity across corn furnaces installed under a Focus program will be 10% greater for corn-burning furnaces compared to fossil fuel furnaces. But as stated earlier we expect the corn furnace to be used for only 80% of the home heating. So the annual electricity savings will be negative by one tenth of the value of gas savings for each furnace scenario.

The situation is different for stoves. First, when the stove is providing the heat rather than the existing gas furnace, the electrical requirements are lower. As stated earlier the furnace will use about 1 kWh per therm of heating gas. The blower on the stove will require about 40% of the energy the furnace fan will need. This estimate assumes that some homeowners will use a fan or two to circulate some of the energy toward other rooms. Thus the electricity requirements for heating the home will be reduced by the difference in the loads between the furnace and the stove for 70% of the time that the stove is heating the home. This results in positive savings for the stove installation while the savings are negative for the furnace installation.

The electricity savings (negative or positive) are shown in the tables above.

*Energy Rates*

There are significant fossil fuel cost savings available through burning corn for home heating. However, this savings are reduced by the cost of the corn used to heat the home. We estimated the cost of heating the modeled homes based on our assessment of average costs of energies used by the furnaces.

Cost of Natural Gas – At least some homeowners in Wisconsin saw $1.60 natural gas in October last year (2005). The weighted average cost of natural gas for MG&E customers last winter was $1.25 per therm. The impact of hurricane Katrina is given some of the credit for the October spike but it is generally agreed that the cost of gas will not slide to the historically low prices witnessed in Wisconsin.

For this analysis we use a first year natural gas price of $1.10 per therm. This is below the average cost for last winter.

Cost of Electricity - The average cost of electricity in Wisconsin for last winter was about $0.10 per kWh. The residential price of electricity in the winter is not as volatile as heating fuels. We inflate this price for this first year analysis by 3% for a cost of electricity of $0.103 per kWh.

Cost of Corn - The cost of corn unexpectedly peaked this year at over $4.00 per bushel (Chicago Board of Trade, CBoT). We discuss the levers for corn pricing in another section. But in general, the long term CBoT price of corn has varied between $2.00 and $2.50 per bushel - with infrequent peaks such as the one seen this year.

The key most-discussed drivers to potential long-term increases in corn prices include the proliferation of ethanol and increases in world demand for corn. However, most of the corn industry professionals we have spoken to would put the medium-term CBoT price for corn at near $2.50 per bushel.

We use an average mid-term price of corn as prefaced in the “State of the Industry” section based on two existing pricing scenarios. The Cost Conscious and Socially Conscious prices used in the B/C analysis are $2.50 per bushel ($89/ton) and $3.60 per 40# bag ($5.00 per bushel, $179/ton).

Cost of Pellets - While analysis of the cost of burning wood pellets is not part of the original scope of this project, we extend the B/C analysis of this fuel because it is the dominant fuel used by those who install biomass stoves and furnaces. In addition, the industry is moving to multi-fuel stoves and furnaces - and pellets will be considered by many homeowners interested in reducing their fossil fuel costs.

Unfortunately, the price of pellets, which is almost exclusively sold in 40# or 50# bags, is high - and comparable to the cost of the corn sold in bags. The going price of pellets is about $4.25 per 40# bag ($213 ton). This is believed to be artificially inflated to take advantage of the moment of high corn prices – as well as influenced by the shortage of pellets last year. A more likely, yet still high, long term price of pellets through the dominant current channels is about $180 per ton ($3.60 per 40# bag).

Cost of LP Gas – We also looked at the economics of replacing LP gas furnaces with corn-burning furnaces because there are significant environmental benefits and the cost of LP gas is significantly higher than that of natural gas - resulting in better economics for corn burning. While this also is not part of the scope of this project we believe this analysis might be useful to a state wide interest in how Wisconsin might reduce its dependence on imported LP gas.

For the LP gas base case analyses, we use a cost of $1.65 per gallon based on price curves from the upcoming WI Energy Statistics report from DOA.

It is instructive to compare the price of the fuels in terms of a common energy unit. It is difficult to compare $1.10 per therm to $2.50 per bushel and know which one is a better buy. The typical approach to comparing heating energy costs across fuels is to express each of the fuels in terms of $ per million Btus purchased. The following table does this for the fuels discussed above and some other fuels.

| **Comparative Cost of Typical heating fuels** | | | | | | |
|---|---|---|---|---|---|---|
| **Fuel** | **Unit** | **Price/unit** | **Btu/unit** | **$/mmBtu resource** | **Efficiency** | **$/mmBtu delivered** |
| Fuel Oil (No. 2) | Gallon | $2.39 | 138,690 | $17.26 | 80% | $21.58 |
| Electricity | kWh | $0.103 | 3,412 | $30.19 | 99% | $30.49 |
| Natural Gas - Atmospheric | Therm | $1.10 | 100,000 | $11.00 | 80% | $13.75 |
| Natural Gas - Condensing | Therm | $1.10 | 100,000 | $11.00 | 92% | $11.96 |
| Propane - Atmospheric | Gallon | $1.65 | 91,333 | $18.07 | 80% | $22.58 |
| Propane - Condensing | Gallon | $1.65 | 91,333 | $18.07 | 92% | $19.64 |
| Wood *** | Cord | $180 | 20,000,000 | $9.00 | 60% | $15.00 |
| Pellet Furnace | Ton | $180 | 16,500,000 | $10.91 | 80% | $13.64 |
| Corn Furnace (#2, 15.5%, fines) | Bushel | $2.50 | 390,320 | $6.41 | 80% | $8.81 |
| Corn Furnace (#2, 12%, clean) | Bushel | $5.00 | 406,560 | $12.30 | 80% | $17.37 |
| Kerosene Furnace | Gallon | $2.87 | 135,000 | $21.26 | 80% | $26.57 |
| Coal Furnace | Ton | $100 | 24,916,000 | $4.01 | 70% | $5.73 |

This table allows several observations. First, the cost of “Value Conscious” corn (12%, clean) is significantly higher than “Cost Conscious” corn (15.5%, with fines) and will much less likely provide an acceptable payback to many prospects. Second, the cost of pellet fuel is about the same as natural gas at a natural gas price of $1.10 per therm. Thus at current pellet prices this fuel cannot compete with natural gas. Third, the cost of LP gas is significantly higher than most of the fuels considered in this study. So it is likely that corn furnaces (using either Cost or Value corn) can compete with LP gas.

Another way to look at this is to compare the price of an alternative fuel necessary to compete with a given natural gas price - not yet accounting for the capital costs of the alternative fuel furnace. The following is an example of this for corn compared to natural gas.

| **Breakeven Cost Table** (Cost Conscious 15.5%, 56 lb/bushel, 6,970 Btu/bushel corn) | | | | | |
|---|---|---|---|---|---|
| ******Equivalent Cost for sales units shown******* | | | Cost per mmBtu | Gas Break Even - Cost/therm | |
| Cost per bushel | Cost per ton | Cost per 40# bag | 80% Corn Furnace | 80% Furnace | 92% Furnace |
| **$2.00** | **$71.43** | **$1.43** | **$5.12** | **$0.51** | **$0.59** |
| $2.25 | $80.36 | $1.61 | $5.76 | $0.58 | $0.66 |
| $2.50 | $89.29 | $1.79 | $6.41 | $0.64 | $0.74 |
| $2.75 | $98.21 | $1.96 | $7.05 | $0.70 | $0.81 |
| **$3.00** | **$107.14** | **$2.14** | **$7.69** | **$0.77** | **$0.88** |
| $3.25 | $116.07 | $2.32 | $8.33 | $0.83 | $0.96 |
| $3.50 | $125.00 | $2.50 | $8.97 | $0.90 | $1.03 |
| $3.75 | $133.93 | $2.68 | $9.61 | $0.96 | $1.10 |
| **$4.00** | **$142.86** | **$2.86** | **$10.25** | **$1.02** | **$1.18** |
| $4.25 | $151.79 | $3.04 | $10.89 | $1.09 | $1.25 |
| $4.50 | $160.71 | $3.21 | $11.53 | $1.15 | $1.33 |
| $4.75 | $169.64 | $3.39 | $12.17 | $1.22 | $1.40 |
| **$5.00** | **$178.57** | **$3.57** | **$12.81** | **$1.28** | **$1.47** |
| $5.25 | $187.50 | $3.75 | $13.45 | $1.35 | $1.55 |
| $5.50 | $196.43 | $3.93 | $14.09 | $1.41 | $1.62 |
| $5.75 | $205.36 | $4.11 | $14.73 | $1.47 | $1.69 |
| **$6.00** | **$214.29** | **$4.29** | **$15.37** | **$1.54** | **$1.77** |

Example: If 15.5% corn costs $4.00 per bushel (or $2.86 per bag), gas must cost more then $1.02 per therm for an 80% gas furnace or more than $1.18 per therm for a 92% gas furnace to break even. That is, break even on the fuel costs – i.e. ignoring corn furnace capital costs and extra work to handle the corn.

Similar tables can be created for other fossil fuels. And a table comparing LP gas to corn would put corn in a much better light.

*Energy Cost Savings*

We use the energy savings and fuel prices to estimate the customer heating cost savings for a variety of scenarios.

*Furnace Gas Cost Savings* - We assume that in the average home in an average year the homeowner will displace 80% of the fossil fuel use of the average of previous years. That is, they will burn enough corn to satisfy 80% of the homes heating needs – and burn fossil fuels for the remaining 20% of the heating needs. This is based on review of several homes' energy use of both corn and fossil fuels over two or more years. For example, one corn burner in Indiana who had data displaced about 90%-95% of his fossil fuels while another corn burner in Wisconsin displaced about 70% of his typical fossil fuels.

We analyzed the energy electric and gas cost savings for a variety of fuel and other parameter scenarios for corn or pellet burning compared to natural and LP gas. These are summarized in the following table.

| **Annual Energy Cost Savings for Scenarios Shown (for Corn-Burning FURNACE Installation)** | **Savings** (By Furnace Type) | |
|---|---|---|
| Scenario: | Natural Gas | LP Gas |
| Cost Conscious Corn vs. Natural gas (Existing Home, 80%) | $506 | $1,282 |
| Cost Conscious Corn vs. Natural gas (Existing Home, 92%) | $440 | $1,115 |
| Cost Conscious Corn vs. Natural gas (New Home, 80%) | $337 | $855 |
| Cost Conscious Corn vs. Natural gas (New Home, 92%) | $293 | $743 |
| Value Conscious Corn vs. Natural gas (Existing Home, 80%) | -$155 | $622 |
| Value Conscious Corn vs. Natural gas (Existing Home, 92%) | -$135 | $541 |
| Value Conscious Corn vs. Natural gas (New Home, 80%) | -$103 | $415 |
| Value Conscious Corn vs. Natural gas (New Home, 92%) | -$90 | $361 |
| Wood Pellets Corn vs. Natural gas (Existing Home, 80%) | $1 | $778 |
| Wood Pellets Corn vs. Natural gas (Existing Home, 92%) | $1 | $676 |
| Wood Pellets Corn vs. Natural gas (New Home, 80%) | $1 | $518 |
| Wood Pellets Corn vs. Natural gas (New Home, 92%) | $1 | $451 |

Natural Gas @ $1.10/therm, Cost Conscious Corn @ $2.50/bu, Cost Value Corn @ $5.00 per 40# bag. Pellets @ 3.60 per 40# bag.

This table shows that if the homeowner burns the 40# bags of corn at current prices, they will spend more to heat their home than if they use natural gas regardless of the age of the home. However, they may save by burning less expensive (Cost-conscious) corn from a nearby farmer.

It also shows that if the homeowner is currently using LP gas all of the biomass alternatives provide energy cost savings.

We performed the same analysis for the situations where the customer will install a corn-burning stove instead of a furnace. The next table shows the results of this analysis.

| **Annual Energy Cost Savings for Scenarios Shown (for Corn-Burning STOVE Installation)** | **Savings** (By Furnace Type) | |
|---|---|---|
| Scenario: | Natural Gas | LP Gas |
| Cost Conscious Corn vs. Natural gas (Existing Home, 80%) | $499 | $1,282 |
| Cost Conscious Corn vs. Natural gas (Existing Home, 92%) | $434 | $1,115 |
| Cost Conscious Corn vs. Natural gas (New Home, 80%) | $333 | $855 |
| Cost Conscious Corn vs. Natural gas (New Home, 92%) | $289 | $743 |
| Value Conscious Corn vs. Natural gas (Existing Home, 80%) | -$79 | $622 |
| Value Conscious Corn vs. Natural gas (Existing Home, 92%) | -$78 | $541 |
| Value Conscious Corn vs. Natural gas (New Home, 80%) | -$53 | $415 |
| Value Conscious Corn vs. Natural gas (New Home, 92%) | -$46 | $361 |
| Wood Pellets Corn vs. Natural gas (Existing Home, 80%) | $57 | $778 |
| Wood Pellets Corn vs. Natural gas (Existing Home, 92%) | $50 | $676 |
| Wood Pellets Corn vs. Natural gas (New Home, 80%) | $38 | $518 |
| Wood Pellets Corn vs. Natural gas (New Home, 92%) | $33 | $451 |

Natural Gas @ $1.10/therm, Cost Conscious Corn @ $2.50/bu, Cost Value Corn @ $5.00 per 40# bag. Pellets @ 3.60 per 40# bag.

This table shows nearly the same energy cost savings from using the stove as there are from using the furnace. This is because while the stove saves less gas, it saves significant electrical energy. And the cost of electricity is about twice the cost of gas.

*Technology Lifetime*

We use a 15 year lifetime for the B/C tests because this is consistent with the lifetime used for other residential heating system Focus program analyses.

*Incremental Cost to Install Technology*

As discussed earlier, it is rare that a homeowner will have a corn-burning system as their only heating system. In most cases the corn furnaces are being installed in homes that already have fossil-fuel furnace - typically natural or LP gas. Therefore, the incremental cost will initially be the full cost of installing the corn-burning appliance.

In New Homes - In new homes, the incremental cost will always be the full cost of the corn-burning system. Thus we apply this assumption to the B/C analysis where either natural or LP gas is the base case fossil fuel. Another new home scenario we analyzed is the case where the customer installs baseboard heating as its “primary” heating system. We assume that in this case the house will have full electric baseboard heating installed for use when the corn furnace is not used. Then the incremental cost is that of baseboard heating plus corn furnace accessories. We estimate the capital investment for the baseboard heating scenarios to be $1,350, $1,805, and $1,370 respectively for the pellet, corn – basic, and corn – value respectively.

In Existing Homes - In the case of an existing homes there will be fossil-fuel appliances whose ages can be anywhere along the term of their lives. The older the existing furnace, the lower the effective incremental cost of installing a corn furnace. On the one hand, if the fossil-fuel furnace was recently replaced, the effective incremental cost will be near the full cost of installing that corn furnace. On the other hand, if the existing fossil-fuel furnace is 20 years old, the incremental cost of the corn-burning furnace will be near zero.

We assume a linear depreciation rate along this age spectrum for the existing home scenario. And I assume that the average age of the existing fossil-fuel furnaces is half of the lifetime of these furnaces. Thus, we discount the incremental cost of the corn furnace to be half the full cost because there is nearly parity between fossil-fuel and corn-burning furnace costs.

The following table shows the components of the cost of installing alternative furnaces and stoves for the scenarios for which we are running the B/C analysis.

| **Investment Costs for Installing Corn Furnaces and Stoves in Homes** | | | | | | |
|---|---|---|---|---|---|---|
| | Furnace System Costs | | | Stove System Costs | | |
| | Pellet | Corn - Basic | Corn - Value | Pellet | Corn - Basic | Corn - Value |
| Furnace Cost | $3,500 | $3,500 | $3,500 | $2,200 | $2,200 | $2,200 |
| Installation Cost | $1,000 | $1,000 | $1,000 | $500 | $500 | $500 |
| Accessories | $100 | $555 | $120 | $100 | $555 | $120 |
| Total Capital Cost | $4,600 | $5,055 | $4,620 | $2,800 | $3,255 | $2,820 |
| Fossil Furnace Depreciation – New Construction | 0% | 0% | 0% | 0% | 0% | 0% |
| Effective Capital Cost – New Construction | $4,600 | $5,055 | $4,620 | $2,800 | $3,255 | $2,820 |
| Fossil Furnace Depreciation – Existing Home | 50% | 50% | 50% | 50% | 50% | 50% |
| Effective Capital Cost – Existing Home | $2,300 | $2,528 | $2,310 | $1,400 | $1,628 | $1,410 |

This table shows that for all new-home scenarios we assume the incremental cost of the corn-burning furnace to be the full “Total Capital Cost” - no replacement depreciation. It further shows that we assume an average depreciation adjustment of the installation cost for homes with fossil-fuel furnaces currently installed.

The total installed cost is different for the three furnaces because the cost of the accessories is different. The same is true for those who purchase stoves. For example, the cost of accessories for those participants who will buy the lower cost corn from the farmer (Cost Conscious scenario) will need accessories to clean and handle the corn. While the participant who chooses to purchase corn at a retail outlet (Value Conscious scenario) will have a lower accessory cost.

The accessory costs we have identified are shown in the table below.

| **Costs of Accessories required to burn corn** | | | |
|---|---|---|---|
| | Pellets | Corn - Basic | Corn - Value |
| Auto maintenance | $100 | $100 | $100 |
| Shop-Vac | | $100 | |
| Tubs or Bags | | $35 | |
| Shur-Kleen corn cleaner | | $300 | |
| Igniting supplies | | $20 | $20 |
| Total Accessory Cost = | $100 | $555 | $120 |

*<u>Program Costs, Participation, and Free Ridership</u>*
We discussed and itemized the projected program costs in the “Program Design” section earlier. We summarize these for the three potential programs here.

| **Cost Components for Potential Programs** | | | | |
|---|---|---|---|---|
| Component | Information Only | Info + Rebate | Info + Support | Info + Support + Rebate |
| Variable Admin | $5,000 | $10,500 | $7,500 | $14,000 |
| Fixed Admin | $50,000 | $50,000 | $100,000 | $100,000 |
| Incentive (Not in program cost) | $0/participant | $500/participant | $0/participant | $500/participant |
| Program Cost | $55,000 | $60,500 | $107,500 | $114,000 |
| Participants | 1,000 | 1,500 | 1,500 | 2,000 |
| Free Ridership | 40% | 30% | 30% | 20% |

The table shows that as more effort is put into delivering the program the participation rate can be expected to be higher and the free ridership lower.

*<u>Benefit/Cost Analysis Results</u>*
We look at the benefits and costs from both the customer and the public benefits industry perspectives.

Customer B/C Results (Payback) - The Focus B/C analysis does not include the participant’s perspective. However, it is necessary to analyze the purchase of corn-burning appliances from the homeowner’s perspective. This is instructive in not only knowing if and under what conditions the technology will be accepted by homeowners. It is also necessary to understand the participant economics in order to design a program that will effect change in the market penetration.

In previous sections we presented the customer energy cost savings and incremental costs for installing corn and pellet furnaces under several scenarios. We have analyzed the payback periods that the purchasers are likely to witness for these technology/cost scenarios.

The following table summarizes the payback periods for a variety of scenarios for furnaces. This is followed by a similar table for stove purchasers. The row colors reflect the different bio-fuels analyzed.

| **Payback Periods (in years) for Selected Scenarios - FURNACE** | | | | | | |
|---|---|---|---|---|---|---|
| **Scenario:** | **Natural Gas** | | | **LP Gas** | | |
| | **Savings** | **Cost** | **Payback** | **Savings** | **Cost** | **Payback** |
| Cost Conscious (Existing 80%) | $506 | $2,528 | 5 | $1,282 | $2,528 | 2 |
| Cost Conscious (Existing 92%) | $440 | $2,528 | 6 | $1,115 | $2,528 | 2 |
| Cost Conscious (New 80%) | $337 | $5,055 | 15 | $861 | $5,055 | 6 |
| Cost Conscious (New 92%) | $293 | $5,055 | 17 | $749 | $5,055 | 7 |
| Cost Conscious (New 92%, Electric) | $93 | $2,055 | 22 | $662 | $2,055 | 3 |
| Value Conscious (Existing 80%) | -$155 | $2,310 | -15 | $662 | $2,310 | 4 |
| Value Conscious (Existing 92%) | -$135 | $2,310 | -17 | $541 | $2,310 | 4 |
| Value Conscious (New 80%) | -$103 | $4,620 | -45 | $421 | $4,620 | 11 |
| Value Conscious (New 92%) | -$90 | $4,620 | -52 | $366 | $4,620 | 13 |
| Value Conscious (New 92%, Electric) | -$290 | $1,620 | -6 | $280 | $1,620 | 6 |
| Wood Pellets (Existing 80%) | $1 | $2,300 | 2,412 | $778 | $2,300 | 3 |
| Wood Pellets (Existing 92%) | $1 | $2,300 | 2,774 | $676 | $2,300 | 4 |
| Wood Pellets (New 80%) | $1 | $4,600 | 7,237 | $525 | $4,600 | 9 |
| Wood Pellets (New 92%) | $1 | $4,600 | 8,322 | $456 | $4,600 | 10 |
| Wood Pellets (New 92%, Electric) | -$200 | $1,600 | -8 | $370 | $1,600 | 4 |

Natural Gas @ $1.10/therm, LP Gas at #1.65 per gallon, Cost Conscious Corn @ $2.50/bu, Cost Value Corn @ $5.00 per 40# bag, Pellets @ $180 per ton. New and Existing in the first column indicate new homes or existing homes. Efficiencies in the first column are assumed for the fossil-fuel furnaces.

| Payback Periods (in years) for Selected Scenarios - <u>STOVE</u> | | | | | | |
|---|---|---|---|---|---|---|
| **Scenario:** | **Natural Gas** | | | **LP Gas** | | |
| | **Savings** | **Cost** | **Payback** | **Savings** | **Cost** | **Payback** |
| Cost Conscious (Existing 80%) | $499 | $1,628 | 3 | $1,187 | $1,628 | 1 |
| Cost Conscious (Existing 92%) | $434 | $1,628 | 4 | $1,032 | $1,628 | 2 |
| Cost Conscious (New 80%) | $333 | $3,255 | 10 | $791 | $3,255 | 4 |
| Cost Conscious (New 92%) | $289 | $3,255 | 11 | $688 | $3,255 | 5 |
| Cost Conscious (New 92%, Electric) | -$267 | $2,155 | -196 | $555 | $2,155 | 4 |
| Value Conscious (Existing 80%) | -$79 | $1,410 | -18 | $609 | $1,410 | 2 |
| Value Conscious (Existing 92%) | -$78 | $1,410 | -18 | $529 | $1,410 | 3 |
| Value Conscious (New 80%) | -$53 | $2,820 | -54 | $406 | $2,820 | 7 |
| Value Conscious (New 92%) | -$46 | $2,820 | -62 | $355 | $2,820 | 8 |
| Value Conscious (New 92%, Electric) | -$346 | $1,720 | -5 | $224 | $1,720 | 7 |
| Wood Pellets (Existing 80%) | $57 | $1,400 | 24 | $745 | $1,400 | 2 |
| Wood Pellets (Existing 92%) | $50 | $1,400 | 28 | $648 | $1,400 | 2 |
| Wood Pellets (New 80%) | $38 | $2,800 | 73 | $495 | $2,800 | 6 |
| Wood Pellets (New 92%) | $33 | $2,800 | 84 | $432 | $2,800 | 6 |
| Wood Pellets (New 92%, Electric) | -$267 | $1,700 | -6 | $302 | $1,700 | 6 |

Natural Gas @ $1.10/therm, LP Gas at $1.65 per gallon, Cost Conscious Corn @ $2.50/bu, Cost Value Corn @ $5.00 per 40# bag, Pellets @ $180 per ton. New and Existing in the first column indicate new homes or existing homes. Efficiencies in the first column are assumed for the fossil-fuel furnaces.

From the customer perspective, the scenario/fuel combinations that are shaded green have reasonable payback periods. Un-shaded scenarios likely will not result in significant penetrations of corn or wood pellet furnaces.

We learned that there is a special market that deserves a little attention. The largest manufacturer of corn-burning furnaces and stoves told us that a majority of their sales are to farmers who live in older homes and grow the corn they burn. Under these conditions, their cost of corn is lower than the market value at the production cost of about $2.00 per bushel. Also, these larger older homes are less efficient than the average stock of homes in Wisconsin by as much as 50%. Based on these market conditions, we recalculated the payback for the Cost Conscious, Existing Home with 80% and 92% fossil-fuel furnace scenarios listed above. These are shown in the following table.

| Payback Periods (in years) for Selected Scenarios - Corn Farmer, FURNACE | | | | | | |
|---|---|---|---|---|---|---|
| **Scenario:** | **Natural Gas** | | | **LP Gas** | | |
| | **Savings** | **Cost** | **Payback** | **Savings** | **Cost** | **Payback** |
| Cost Conscious (Existing 80%) | $640 | $2,528 | 4 | $1,426 | $2,528 | 2 |
| Cost Conscious (Existing 92%) | $556 | $2,528 | 5 | $1240 | $2,528 | 2 |

Natural Gas @ $1.10/therm, LP Gas at #1.65 per gallon, Cost Conscious Corn @ $2.00/bu, Cost Value Corn @ $4.00 per 40# bag. Existing in the first column indicates that only existing homes we modeled. Efficiencies in the first column are assumed for the fossil-fuel furnaces.

This table shows that these corn-burning scenarios have very short payback periods. And looking at the two previous tables, this farmer could shorten these paybacks to about half if his installs a stove instead of a furnace.

Public Benefits Test Results - Using the input parameters values discussed we ran the Total Resource Cost (TRC) test in the Benefit/Cost tool. The TRC test is currently the deciding test for Focus programs.

We ran the furnace and stove scenarios discussed earlier and include the TRC ratios for each in the following table. We have included the customer payback for each scenario to add broader perspective. The payback is in years. The "existing" and "new" in the first column parentheses refer to existing homes (higher heat loads) and new homes (lower heat loads). And the 80% and 92% in those parentheses refer to an installed atmospheric or condensing gas furnace.

| **Payback Periods (in years) for Selected Scenarios - FURNACE** | | | | |
|---|---|---|---|---|
| **Scenario:** | **Natural Gas** | | **LP Gas** | |
| | **TRC** | **Customer Payback** | **TRC** | **Customer Payback** |
| Cost Conscious (Existing 80%) | 1.07 | 5 | 2.29 | 2 |
| Cost Conscious (Existing 92%) | 0.93 | 6 | 2.00 | 2 |
| Cost Conscious (New 80%) | 0.67 | 15 | 1.44 | 6 |
| Cost Conscious (New 92%) | 0.58 | | 1.25 | 7 |
| Cost Conscious (New 92%, Electric) | 1.33 | 22 | 2.55 | 3 |
| Value Conscious (Existing 80%) | 0.66 | -15 | 1.42 | 4 |
| Value Conscious (Existing 92%) | 0.58 | -17 | 1.24 | 4 |
| Value Conscious (New 80%) | 0.50 | -45 | 1.06 | 11 |
| Value Conscious (New 92%) | 0.43 | -52 | 0.93 | 13 |
| Value Conscious (New 92%, Electric) | 0.86 | -6 | 1.64 | 6 |
| Wood Pellets (Existing 80%) | 0.84 | 2,412 | 1.81 | 3 |
| Wood Pellets (Existing 92%) | 0.74 | 2,774 | 1.58 | 4 |
| Wood Pellets (New 80%) | 0.59 | 7,237 | 1.27 | 9 |
| Wood Pellets (New 92%) | 0.51 | 8,322 | 1.10 | 10 |
| Wood Pellets (New 92%, Electric) | 1.09 | -8 | 2.10 | 4 |

| Payback Periods (in years) for Selected Scenarios - **STOVE** | | | | |
|---|---|---|---|---|
| **Scenario:** | **Natural Gas** | | **LP Gas** | |
| | **TRC** | **Customer Payback** | **TRC** | **Customer Payback** |
| Cost Conscious (Existing 80%) | 1.19 | 3 | 2.52 | 1 |
| Cost Conscious (Existing 92%) | 1.03 | 4 | 2.19 | 2 |
| Cost Conscious (New 80%) | 0.81 | 10 | 1.70 | 4 |
| Cost Conscious (New 92%) | 0.70 | 11 | 1.49 | 5 |
| Cost Conscious (New 92%, Electric) | 1.43 | -196 | 2.65 | 4 |
| Value Conscious (Existing 80%) | 0.71 | -18 | 1.51 | 2 |
| Value Conscious (Existing 92%) | 0.62 | -18 | 1.32 | 3 |
| Value Conscious (New 80%) | 0.57 | -54 | 1.21 | 7 |
| Value Conscious (New 92%) | 0.50 | -62 | 1.06 | 8 |
| Value Conscious (New 92%, Electric) | 0.93 | -5 | 1.72 | 7 |
| Wood Pellets (Existing 80%) | 0.92 | 24 | 1.96 | 2 |
| Wood Pellets (Existing 92%) | 0.81 | 28 | 1.71 | 2 |
| Wood Pellets (New 80%) | 0.70 | 73 | 1.48 | 6 |
| Wood Pellets (New 92%) | 0.61 | 84 | 1.30 | 6 |
| Wood Pellets (New 92%, Electric) | 1.19 | -6 | 2.19 | 6 |

Cells that are shaded **green** pass the test. The cells that are **brighter green** are those that pass the tests for stoves but did not pass for furnaces. Those not shaded do not pass the test. Passing the test for TRC is that it is greater than 1.00. Passing from the emissions perspective is a positive savings in $CO_2$. Passing from the customer perspective is a payback of 17 years or less.

These tables show several things. First, corn-burners fare better where the home is heated with LP gas compared to natural gas. Second, where natural gas is intended to be displaced, the house needs to have high heating loads and cost of corn needs to be reasonably low for a program to pass the TRC test.

## Environmental, Economic, and Social Implications

As with all conservation and renewable energy programs, part of the impetus is to reduce our footprint on the environment while heating our homes. Burning corn is believed to do this.

However, because corn burning is currently at nascent levels no research was found that quantifies the emissions from their combustion vents. Thus, we can only partially account for the environmental benefits of burning corn.

### *Approach*

We spoke with a diverse group of actors in the corn burning industry. These include persons from air emissions regulatory bodies, manufacturers, universities, and industry associations. Each lamented that there are no published data on the emissions from any corn burning appliances.

The federal Environmental Protection Agency (EPA) generally develops “emissions factors” for the many energy sources. We are all familiar with emissions factors for electrical generation and end-use appliances such as natural gas, LP gas and oil furnaces in homes. Emissions factors for cars and cordwood stoves have been developed. And there are even some estimates of emissions from pellet stoves. So why not corn burning stoves and furnaces? The simple answer is that the sales of these appliances have not grown to a level that prompted the EPA’s attention until recently.

We spoke with the two major engineering firms that do much of the emissions and efficiency testing for home heating stove appliances (primarily cordwood and pellet stoves). Neither has been hired to do these types of tests for corn burning. One suggested that they expect that this work will be started in 2007. Also, a professor at Michigan University, Saginaw suggested that he will be completing some limited studies of efficiencies and emissions this spring.

We spoke with someone at the Hearth, Patio, and Barbeque Association (HPBA) who works with their members (manufacturers) on these issues. He suggested that they are having discussions with their members about measuring emissions and estimating efficiencies.

Thus, we currently cannot provide insights into what the emissions are from corn burning furnaces or stoves. Accordingly, we cannot accurately estimate the emissions impact of burning corn versus fossil fuels.

We will also discuss some societal and economic implications of burning corn.

***Environmental Benefits***
Our research has uncovered some insights into the environmental benefits of corn burning for home heating.

We discuss three separable, ***not-fully-quantified*** environmental issues surrounding corn burning:
- Reduced $CO_2$ emissions
- Reduced or increased other emissions
- Net energy from burning corn

We have ***partially*** analyzed the environmental impact of burning corn for home heating. As part of the customer and program benefit/cost analyses we have determined the gas and electricity savings from burning corn instead of conventional fuels. From this analysis and available “emissions factors” used for conventional fuels, we can calculate the amount of the standard compounds that are not emitted due to the reduced use of these conventional fuels. Unfortunately, there has been no research to date measuring the pollutants from corn burning appliances. This means we cannot accurately calculate the emissions that are **displaced** by converting from fossil fuels to corn. This is why emissions impacts are not discussed in the report.

The lack of data on emissions from corn burning is due to two reasons. First, the sales of these appliances have been insignificant from the pollution contribution perspective of the U.S. EPA. They have not required these data to be provided because the cumulative contributions have been very small – because sales have been small. Second, the EPA has been convinced, based on anecdotal evidence it has collected, that the emissions from individual appliances are small. Based on this, corn-burning appliances are classified as “exempt” from emissions measurement and publication requirements – as are certain newer wood-pellet burning appliances. This would imply that the emissions of corn-burning furnaces are considered negligible at this time and if this is reasonable, these emissions would only minimally mitigate the fossil-fuel emissions reductions.

The above caveat being emphasized, we include here tables and text discussing the amount of the pollutants (typically considered) that are not emitted due to reduced use of fossil fuels.

The first table shows these emissions *reductions* where a FURNACE is installed in the home. The second table shows the same for installing a STOVE in the home.

| Scenario - **FURNACE** | Energy Savings | Emissions Reductions | | | |
|---|---|---|---|---|---|
| | | | | | |
| **Natural Gas** | Therms | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | 896 | 10,542 | 0.053 | 8.79 | 2.29 E-05 |
| Existing Home, Condensing | 780 | 9,167 | 0.046 | 7.64 | 1.99 E-05 |
| New Home, Atmospheric | 598 | 7,028 | 0.035 | 5.86 | 1.52 E-05 |
| New Home, Condensing | 520 | 6,111 | 0.031 | 5.09 | 1.32 E-05 |
| Electric | kWh | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | (90) | (199) | -1.094 | -0.51 | -4.4E-06 |
| Existing Home, Condensing | (78) | (173) | -0.951 | -0.44 | -3.8E-06 |
| New Home, Atmospheric | (60) | (132) | -0.729 | -0.34 | -2.9E-06 |
| New Home, Condensing | (52) | (115) | -0.634 | -0.30 | -2.5E-06 |
| Total NG Displacement Emissions Savings | | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | | 10,343 | -1.041 | 8.28 | 1.85 E-05 |
| Existing Home, Condensing | | 8,994 | -0.905 | 7.20 | 1.61 E-05 |
| New Home, Atmospheric | | 6,896 | -0.694 | 5.52 | 1.23 E-05 |
| New Home, Condensing | | 5,996 | -0.603 | 4.80 | 1.07 E-05 |
| | | | | | |
| **LP Gas** | Gallons | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | 979 | 12,166 | 1.451 | 13.68 | NA |
| Existing Home, Condensing | 851 | 10,579 | 1.262 | 11.89 | NA |
| New Home, Atmospheric | 652 | 8,111 | 0.967 | 9.12 | NA |
| New Home, Condensing | 567 | 7,053 | 0.841 | 7.93 | NA |
| Electric | kWh | CO2 | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | (90) | (199) | -1.094 | -0.51 | -4.4E-06 |
| Existing Home, Condensing | (78) | (173) | -0.951 | -0.44 | -3.8E-06 |
| New Home, Atmospheric | (60) | (132) | -0.729 | -0.34 | -2.9E-06 |
| New Home, Condensing | (52) | (115) | -0.634 | -0.30 | -2.5E-06 |
| Total LPG Displacement Emissions Savings | | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | | 11,967 | 0.357 | 13.17 | NA |
| Existing Home, Condensing | | 10,406 | 0.311 | 11.45 | NA |
| New Home, Atmospheric | | 7,978 | 0.238 | 8.78 | NA |
| New Home, Condensing | | 6,937 | 0.207 | 7.63 | NA |

| **Scenario - <u>STOVE</u>** | **Energy Savings** | **Emissions Reductions** | | | |
|---|---|---|---|---|---|
| | | | | | |
| **Natural Gas** | Therms | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | 784 | 9,224 | 0.046 | 7.69 | 2.00 E-05 |
| Existing Home, Condensing | 682 | 8,021 | 0.040 | 6.69 | 1.74 E-05 |
| New Home, Atmospheric | 523 | 6,150 | 0.031 | 5.13 | 1.33 E-05 |
| New Home, Condensing | 455 | 5,347 | 0.027 | 4.46 | 1.16 E-05 |
| Electric | kWh | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | 471 | 1,043 | 5.742 | 2.68 | 2.30E-05 |
| Existing Home, Condensing | 409 | 907 | 4.993 | 2.33 | 2.00E-05 |
| New Home, Atmospheric | 314 | 695 | 3.828 | 1.79 | 1.53E-05 |
| New Home, Condensing | 273 | 605 | 3.329 | 1.56 | 1.33E-05 |
| Total NG Displacement Emissions Savings | | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | | 10,267 | 5.788 | 10.37 | 4.30 E-05 |
| Existing Home, Condensing | | 8,928 | 5.033 | 9.02 | 3.74 E-05 |
| New Home, Atmospheric | | 6,845 | 3.859 | 6.92 | 2.87 E-05 |
| New Home, Condensing | | 5,952 | 3.355 | 6.01 | 2.49 E-05 |
| | | | | | |
| **LP Gas** | Gallons | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | 856 | 10,645 | 1.269 | 11.97 | NA |
| Existing Home, Condensing | 745 | 9,257 | 1.104 | 10.41 | NA |
| New Home, Atmospheric | 571 | 7,097 | 0.846 | 7.98 | NA |
| New Home, Condensing | 496 | 6,171 | 0.736 | 6.94 | NA |
| Electric | kWh | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | 471 | 1,043 | 5.742 | 2.68 | 2.3E-05 |
| Existing Home, Condensing | 409 | 907 | 4.993 | 2.33 | 2.0E-05 |
| New Home, Atmospheric | 314 | 695 | 3.828 | 1.79 | 1.5E-05 |
| New Home, Condensing | 273 | 605 | 3.329 | 1.56 | 1.3E-05 |
| Total LPG Displacement Emissions Savings | | $CO_2$ | $SO_2$ | NOx | Hg |
| Existing Home, Atmospheric | | 11,688 | 7.011 | 14.65 | NA |
| Existing Home, Condensing | | 10,163 | 6.097 | 12.74 | NA |
| New Home, Atmospheric | | 7,792 | 4.674 | 9.77 | NA |
| New Home, Condensing | | 6,776 | 4.064 | 8.49 | NA |

And the emissions displacement from burning less natural or LP gas in a new home (and with electric heating as the “primary” heating source) are shown in the following table.

| **Scenario - FURNACE** | **Energy Savings** | **Emissions Reductions** | | | |
|---|---|---|---|---|---|
| | | | | | |
| Natural Gas Displacement | Therms or kWh | $CO_2$ | $SO_2$ | NOx | Hg |
| Gas Savings | 650 | 7,639 | 0.038 | 6.37 | 1.7E-05 |
| Electric Savings (Negative) | (3,678) | (8,150) | -44.869 | -20.96 | -1.8E-04 |
| Total for NG Displacement = | | (511) | -44.831 | -14.59 | -1.6E-04 |
| | | | | | |
| LP Gas Displacement | Gallons or kWh | $CO_2$ | $SO_2$ | NOx | Hg |
| Gas Savings | 709 | 8,816 | 1.051 | 9.91 | NA |
| Electric Savings (Negative) | (3,678) | (8,150) | -44.869 | -20.96 | -1.8E-04 |
| Total for LPG Displacement = | | 666 | -43.817 | -11.05 | NA |

This table shows that burning corn in a FURNACE with electric heat as a backup is not an environmentally friendly option – whether NG or LPG is displaced.

And the same table for the installation of a stove instead of a furnace.

| **Scenario – STOVE** | **Energy Savings** | **Emissions Reductions** | | | |
|---|---|---|---|---|---|
| | | | | | |
| Natural Gas Displacement | Therms or kWh | $CO_2$ | $SO_2$ | NOx | Hg |
| Gas Savings | 650 | 7,639 | 0.038 | 6.37 | 1.7E-05 |
| Electric Savings (Negative) | (5,244) | (11,620) | -63.975 | -29.89 | -2.6E-04 |
| Total for NG Displacement = | | (3,981) | -63.936 | -23.52 | -2.4E-04 |
| | | | | | |
| LP Gas Displacement | Gallons or kWh | $CO_2$ | $SO_2$ | NOx | Hg |
| Gas Savings | 709 | 8,816 | 1.051 | 9.91 | NA |
| Electric Savings (Negative) | (5,244) | (11,620) | -63.975 | -29.89 | -2.6E-04 |
| Total for LPG Displacement = | | (2,805) | -62.923 | -19.98 | NA |

This table shows that burning corn in a STOVE with electric heat as a backup is not an environmentally friendly option – whether NG or LPG is displaced.

From an environmental perspective, the electric heat scenario is no friend. And there is a greater risk of increased negative environmental (as well as economic) impact should the amount of corn being burned be less than the assumed fractions of heating.

Carbon Dioxide ($CO_2$)

The table shows that there are significant reductions in $CO_2$ emissions available through displaced 80% of the home’s fossil fuels.

$CO_2$ released from burning fossil fuels has been locked in the fuel for millions of years. This $CO_2$ is primarily accepted as a major contributor to global warming. The $CO_2$ emitted to the atmosphere as a result of burning corn has not been *locked up* underground for long. This corn-burn based $CO_2$ was extracted from the atmosphere about four to nine months prior to the burning. This leads some to say that corn burning is $CO_2$ neutral. While this is generous, it has basis. What makes it inaccurate is that fossil fuels are utilized in the process chain from growing the corn to getting it to the home.

Below we show an analysis of the *net energy* of growing and burning corn. The input energy identified in that analysis results in emissions of $CO_2$. However, one cannot just say that $CO_2$ savings should be subtracted from the $CO_2$ savings shown above. There is significant energy use and related emissions from extracting natural or LP gas from wells in the U.S., and the Mid-East and African continents, and bringing it to homes. The emissions impact of the “embodied energy” use is not accounted for the conventional fuels – we do not account for it for corn burning either in this report.

Nitrous Oxides, Sulfurous Oxides, Mercury

Those of us interested in quantifying environmental benefits from conservation and renewable energy programs usually measure this in terms of not only $CO_2$ but also NOx, SOx, and Mercury reductions.

In the table above we show the reductions in these pollutants from reductions in use of natural and LP gas and electricity. Unfortunately, there has been no research to date measuring the pollutants from corn burning appliances.

This is due to two reasons. First, the sales of these appliances have been insignificant from the pollution contribution perspective of the U.S. EPA. They have not required these data to be provided because the cumulative contributions have been very small – because sales have been small. Second, the EPA has been convinced, based on anecdotal evidence it has collected, that the emissions from individual appliances are small. Based on this, corn-burning appliances are classified as “exempt” from emissions measurement and publication requirements – as are certain newer wood-pellet burning appliances.

This would imply that the emissions of corn-burning furnaces are considered negligible at this time and if this is reasonable, these emissions would only minimally mitigate the fossil-fuel emissions reductions shown in the table above.

A final reminder - our analysis above looks only at the reductions in emissions from displacing some of the fossil fuels in homes that will burn corn. Because there are no data available yet on the emissions from corn burning appliances, we are looking at only half of the equation at this time. It is possible that new information will be available after May 2007; contact the author for more information.

Net Energy
There is national discussion about how much energy is needed to create ethanol compared to the energy available in the resulting automotive fuel. While there is at least one energy professional who still argues that ethanol has a negative energy balance, most agree that this is not the case. A similar argument has been proposed for burning corn.

One university professor we spoke with said that the ratio of the energy extracted from burning corn to the energy required to produce and deliver it is about 5:1. That is, for every Btu used to produce and deliver corn to the home, there are five Btus released when burning. We attempt to verify this. Our *tertiary* research and analysis shows the following.

From an analysis looking at the energy used to produce corn in Wisconsin we found the following.

| **Energy Requirements to Produce Corn - WI** | |
|---|---|
| | Btu/bushel |
| 1. Seed | 548 |
| 2. Fertilizers | |
| 2a. Nitrogen | 19,864 |
| 2b. Potash | 1,278 |
| 2c. Phosphate | 1,139 |
| 2d. Lime | 255 |
| 3. Energy: | |
| 3a. Diesel | 8,576 |
| 3b. Gasoline | 1,536 |
| 3c. LPG | 1,241 |
| 3d. Electricity | 470 |
| 3e. N Gas | 986 |
| 4. Custom Work | 2,526 |
| 5. Chemicals | 2,542 |
| 6. Purchased Water | 0 |
| 7. Input Hauling | 251 |
| Total = | **41,212** |

Then we can summarize the above components as follows:

| Summary – Calculation to estimate Net Energy Balance | | | |
|---|---|---|---|
| Energy to grow corn | | 41,212 | Btu/bu |
| Gas Energy to dry to 14% | | 8,090 | Btu/bu |
| Electricity Energy to dry to 14% | | 399 | Btu/bu |
| Energy to transport | | 6,475 | Btu/bu |
| | Total Input = | 56,176 | Btu/bu |
| | Total Output = | 406,560 | Btu/bu |
| | Input Percent of Output = | 13.8% | |
| | Net Energy Balance = | 7.6 | Btu/Btu |

Because this is a very simple and piecemeal approach to estimating energy inputs it is possible that there are elements of the input energy that we have not identified. Thus the net energy balance of 5.0 Btu/btu suggested by a university professor in Michigan seems likely reasonably accurate.

Finally, near completion, as of April 2007, is a study conducted by a student of Dr. John Katers at the U.W. Green Bay, for the Pellet Fuels Institute, which will likely shine some light on embodied energies of some fossil fuels and alternative fuels (including corn).

***Local Economic Benefits***

Of interest to many energy efficiency and renewable energy public benefits programs is shifting from importing energy to home-grown energy solutions.

Most of the energy utilized to heat homes (and for many other uses) is imported to Wisconsin. We have few conventional energy resources in the state. So options for heating homes with local resources will increase jobs and keep money in the state.

Burning corn offers such an opportunity. One of the reasons persons cite for why they purchased a corn furnace is to help their local farmer – rather than send their energy dollars out of the state.

From our discussions with dealers and farmers it is clear that many farmers are interested in selling corn to homeowners who want to burn it. These farmers like the idea of having more control over the price that they can get for their farm – as opposed to the price being dictated by the Chicago Board of Trade (CBoT) and its speculators.

Farmers can make more on the corn and homeowners can save on their cost by splitting the difference in what the farmer gets from the local mill or coop and what the homeowner will pay that mill or coop – if the latter will even bother to sell it to the homeowner.

And more important to both parties is that the profit and savings are kept in the community.

This is a win-win-win for the farmer, corn burner, and the public benefits program.

### *Societal Benefits*

One societal benefit mentioned by a several persons we spoke with is that using locally grown energy sources reduces our dependency on foreign oil and natural gas. Most often this was framed in the context of national security.

## Other Issues and Program Options

During our research and inquiries we identified several other issues that the corn-burning industry deals with. These issues have bearing on how Focus might design a program to decrease use of fossil fuels through increased corn burning.

The issues discussed in this section include:

- Zoning of heating
- Corn vs. Pellet Furnaces
- Natural Gas vs. LP gas displacement
- Federal incentives

### *Zoning of Heating*

A surprising number of persons we spoke with suggested that the capability of zoning that a stove offers over a furnace makes it the option of choice for a lot of homeowners. We think it instructive to a program design to discuss stoves as a program option.

We estimate from our interviews that dealers sell about five corn-burning stoves for every furnace. The primary reason given for this is that there are a number of barriers—from cost to convenience and aesthetics—to installing a furnace and reasons to install a stove instead. In addition, a key benefit of stoves—according to distributors—is the potential for zone heating.

The use of a corn stove to do zone heating is of interest in the development of a program. A number of the dealers said that some of their customers are saving more on their gas bills with a stove than they would with a furnace because they accept that distant bedrooms will be colder so they are not heating the whole house. While we have not analyzed any heating bills to confirm this, it seems reasonable in some cases.

The National Association of Home Builders (NAHB) completed a report in 1994 that looked at the energy savings potential from zoning heated spaces in home. One illustrative finding was that there is as much 27% savings in heating costs for homes that correctly utilize zoning technologies.

This discussion suggests that a Focus program should not target just furnaces but should encourage whatever appliance the customer decides best fits their needs.

**Corn vs. Pellet Furnaces**
We discussed with dealers and manufacturers the use of wood-pellet appliances compared to corn-burning appliances. An earlier table shows that the pellets cost more than “basic” corn but less than the “value” corn currently being sold. This alternative fuel is as competitive against fossil fuels as is corn in some cases.

Pellet stoves and furnaces have been sold in large quantities for a long time now. It appears that they produce less ash and do not create clinkers. Pellet-burning appliances will compete with corn-burning appliances into the future.

Pellet furnaces can displace as much gas as corn, and have what appear to be similarly low emissions. Pellets are produced in Wisconsin for use in local furnaces and stoves and there is room for growth in this production.

There appears to be no overwhelming advantage from a fossil fuel displacement, environmental benefits, or local economy perspective to encourage homeowners to burn corn over other biomass fuels. Furthermore, it seems that manufacturers are moving production to multi-fuel furnaces and stoves. Indeed they talk about future appliances being called biomass burners. They anticipate that these new appliances will handle corn, wood and alfalfa pellets, soy beans, cherry pits, wheat and more and some appliances already do.

One advantage of the multi-fuel appliances is that homeowners have fuel options. If in a given year the cost of corn is high and the cost of pellets or cherry pits is low, the customer can choose to burn the pellets or pits. Then maybe the next year the corn prices may be lower and they can burn corn.

What is important to the design of the program is that fossil fuel burning is reduced, emissions are lowered and the local economy is better supported – for all of these alternative fuel options.  All of this suggests that if a program is designed to increase the penetration of corn-burning furnaces it should be uninterested in what else the appliance can burn.

One last note regarding pellets is that some homeowners who are burning pellets are purchasing the pellets from out of state and even from Canada. This is because there is a belief that the pellets made by the few Wisconsin companies do not offer the same value (price vs. quality) as other out-of-state suppliers. If Focus designs a program that does not discriminate against wood pellets and if purchasing these alternatives locally is important, then Focus should encourage the Wisconsin pellet producers to improve the quality of their product.

***Natural Gas vs. LP gas (and Oil)***

We also analyzed for the displacement of LP gas use by corn-burning furnaces for two reasons. First, far more stoves and furnaces are sold to homeowners who have been primarily heating their homes with LP gas. Second, there is as much or more advantage to the homeowner (LP is significantly more expensive), the environment (LP is slightly dirtier than natural gas), and the local and state economies from displacing LP gas than displacing natural gas.

We believe there is value to considering a program to displace LP gas although we recognize that a program targeting LP gas users would be outside the scope of Focus on Energy at this time. We also note that even if the program targets sales for displacement of only natural gas, sales of corn-burning stoves to homeowners using LP gas are inevitable.

Finally, while the use of #2 Fuel Oil is low compared to use of natural and LP gas, displacement of this fuel is similar to displacement of LP gas. We did not include oil in our energy savings and environmental benefits analyses. However, oil is both significantly more costly and has greater emissions than natural or LP gas. Thus, it may make sense not to exclude from the program homes that will displace oil by burning corn.

***Electric vs. Gas***

We also looked at a new construction scenario where the main furnace is a corn-burning unit and the backup heating system is electric baseboard. We look at this scenario because the benefit/cost analysis shows that installing both a new fossil fuel furnace and corn furnace in the new home does not make sense from either the societal or the customer perspectives.

If a homeowner installs a forced air corn-burning furnace as the primary heat source, they can install baseboard heating as a backup for around $1,500. This is a reasonable incremental cost compared to about $5,000 if they were to install both a gas and a corn furnace.

We ran B/C analyses for a few scenarios for new homes where electric heat is installed as a backup to the corn furnace compared to both natural and LP gas alternatives.

However, we showed earlier that this application does not make sense from an environmental perspective. This is because the expectation that 20% of the heating will be done with the baseboard results in increased power plant emissions that significantly counter the lower emission at the home.

**Federal Incentives**
The 2005 federal energy bill includes an incentive for the purchase of biomass burners. This incentive is structured to be a tax credit of 25% of the cost of a biomass heating system, up to a maximum of $3,000. For the typical corn furnace cost of about $5,000 this incentive would be about $1,250. Unfortunately, this program has not been funded yet. This credit should be considered in the design of any program that Focus might consider for corn-burning appliances. For example, the initial program design might include an incentive that will expire when the federal program is funded. Or conversely, the initial program design might not include a rebate with the expectation that the federal incentive may become available during the first year of the program.

**Possible Program Options & Approaches**
Our experience and this research suggest program options that should be considered in designing a Focus corn-burner program. As can be expected, the options that make the most sense from the customer perspective compliment the options that fare best under the public benefits TRC test.

We analyzed four program approaches:

1. Awareness (and Education) Only
2. Awareness and Rebate
3. Awareness Complemented with Infrastructure Support
4. Awareness and Rebate Complemented with Infrastructure Support

The benefit/cost analysis does not favor any of these options over the other because of the criteria under which it is run. However, the budgets will need to be much greater for any program that includes a rebate. It appears that for a rebate to have significant impact it will have to be at least 10% of the cost of corn-burning technology – or about $500 for a furnace and $300 for a stove.

There is some uncertainty in the medium-term cost of corn. The historic range of costs of corn has been between $2.00 and $2.50 per bushel. However there have been large swings in the last twenty years – the highest being to about $3.25 in 1996. And the cost of corn this year breached $4.00 – but some believe it will come back to the long-term range within a couple of years because of the complicated and dynamic market forces.

While there is a growing, nascent corn-burning infrastructure, it suffers some market imperfections. The most threatening of which is sale of high-priced corn in bags. An infrastructure support component of a program could help guide the market onto a more sustainable path.

Given this uncertainty, we believe a cautious initial program approach is in order.

## Recommendations

Based on the discussion and conclusions, we offer the following recommendations for possible designs of a corn-burner program.

1. Conduct a pilot program – The price of corn is high this year and there is some disagreement on whether it will drop to near historic levels. This suggests that Focus can do some testing of program options under a limited geography and scope in the first year. If the price of corn remains high, Focus can reassess its options for increasing penetration of biomass burners.
2. Target the program tightly in the first year – There appears to be a significant market for corn-burning among farmers who grow corn. The confluence of low cost corn and their living in older homes with greater heating needs makes this a lucrative first market for the program – while it allows the program to improve its capabilities for venturing into other markets in future years.
3. Do not offer rebates in the first year – While some manufacturers and dealers believe a rebate or tax incentive would help move the corn-burning market, others believe rebates are not needed. Furthermore, the federal energy act created in 2005 will (or should eventually) offer a significant tax credit for biomass burners. This could happen in 2007. We suggest that no financial incentive be offered in the first year of the program to allow the program to determine if one is needed. This will also allow time to determine if the federal incentive will start and will make a good complement to the program – keeping Focus program costs down.
4. Facilitate building the market infrastructure – We have seen some natural development of infrastructure for corn-burning. However, Focus could facilitate faster penetration of this technology by coordinating an accelerated development of infrastructure partnerships. Facilitating connection of potential customers to farmers, grain mills, and coops who can provide less expensive corn to them will improve the payback and increase penetration of the technology more quickly. (If prospects have to purchase corn in bags at this channel's current costs, the market growth will likely be hampered.)
5. Provide support to dealers and corn sellers – A key to sustainable growth in corn burning is ensuring that prospects have good, third party information and access to fuels. One of the weaknesses in the market is lack of coordination among the growing number of market players – and Focus can improve this.
6. Do not limit the program to furnaces – It is not clear that furnaces either displace more fossil fuels or offer the best opportunity for a Focus program than stoves. The ability of the homeowner to zone their heating suggests that stoves can offer significant program benefits. Stoves should be considered at least in the first year of the program to allow Focus to better estimate their place in the program.
7. Consider encouraging multi-fuel burners – The market for biomass burners appears to be moving to multi-fuel units. The advantage of these over straight corn-burning units is that the homeowner can alternate among fuels to ensure cost savings – increasing the reliability of burning over time. Entrepreneurs will enter the market with other, more efficacious fuels if the appliances can burn them.

8. Learn in the first couple of years – The uncertainty in corn prices does not necessitate a decision to leave corn-burning appliances out of the mix of technologies and services on the Focus program menu. The environmental, local economy, and customer future energy cost savings suggest that a program makes some sense. Test program ideas in the first couple of years as the market seeks a sustainable position. Proceeding with cautious alacrity will allow Focus to be in position to offer significantly valuable programs in a couple of years.
9. Coordinate with the Wisconsin Office on Energy Independence – It appears that the Wisconsin Office on Energy Independence will coordinate the state's efforts to grow Wisconsin's bio- and renewable economies. This was made public by Governor Doyle during his recent State-of-the-State address as a result of growing acceptance of global warming. This Office will likely be interested in the environmental benefits of corn-burning as well as the local economic benefits. The Focus program should look for a partnership with this office.