CEMSA Energy Planning and Assessment Project

CASE STUDIES Volume 1

Prepared for
The Producer-Members of the
Iowa Soybean Association

By
Douglas B. Johnson, Ph.D.
Environmental Intelligence Inc.

February 2007

Table of Contents

Introduction – Energy Supply, Demand and National Security

For the last 40 years, our nation's environmental priorities have undergone remarkable ebb and flow as national priorities have in some cases stayed the same, and in other cases, shifted considerably. Clean water was an early priority, but, in an era of cheap oil, our first crack at crafting environmental policy didn't say much about energy. Then came OPEC.

In the late 1970s, the rising economic and political power of the OPEC cartel changed the energy and national security picture for the United States. By the end of the 1970s, President Jimmy Carter appeared on television in the famous "sweater talk," in which he extolled the virtues of the nation tackling impending national security and fossil fuel supply/demand issues apparent at the time. Then, we found more oil and gas, and for the time being, the crisis was abated.

We are entering another era of supply and demand issues with our energy supplies. Future oil and gas discoveries will be at deeper depths and higher cost. Diesel fuel, gasoline, LP, and natural gas are vital inputs as fuels and ingredients to modern agriculture. Higher fuel and energy costs will hit agriculture hard.

Agriculture is ever ready to assist the nation with meeting its needs for an expanded supply of fuel from renewable fuels like corn ethanol and soy biodiesel. Agriculture can also help our nation move toward energy independence by reducing our demand for fossil fuels, and becoming more eco-efficient. This Volume 1 Case Study Report describes research findings from a study of the capacity for energy savings to be realized on eleven Iowa farms.

Getting Out In Front: Proactive Producer-Members

Producers face increasing pressure to identify opportunities within their control to improve energy conservation, reduce input costs and preserve operating margins. Roughly 95% of our nation's anhydrous ammonia is produced from natural gas and supplies are becoming tighter with commensurate rise in prices. Recent reports indicate that the rising price of oil is causing major utilities to increase their reliance on natural gas, which increases concern about availability and prices of this critical input to row crop production.[1] Iowa Soybean Association is eager to get out in front of this issue by investing in research and working with producers to identify steps that farmers can take to improve the energy efficiency of their farming operations.

In 2007 MGT Envirotec, a group consisting of several crop consultants and producer-members of Iowa Soybean Association, initiated development of a software tool that would tease out which row-crop farming practices are the most energy intense. With a small grant from NRCS, a first-generation software tool was crafted and piloted with a handful of Iowa producers. Initial use of this tool and methodology yielded early findings that suggested a larger study would likely yield insights into the energy intensity of row crop production across a wide variety of operational practices.

---

[1] More recently (5 Feb 2008), The New York Times reports that climate change concerns are impeding use of coal as a source of fuel, and American utilities are turning to natural gas to meet expected growth in demand. As the *Times* article reports, the last time this happened, natural gas prices tripled.[1]

At the time, these crop consultants were also involved in the CEMSA program, which was busy addressing the most pressing issue of concern to farmers, regulators, the general public and the environmental community: Water quality. Compliance issues have a history of setting the agenda for environmental management issues in agriculture, and CEMSA has sought to get out in front on water quality through nutrient management planning, pest management planning, soil conservation tools, applied evaluation, and other processes to evaluate farm environmental performance and foster recommendations that can reduce environmental impact and save the producer money. Energy was on the list of things to address, but it was not among the top priorities. With rising prices, energy resources for agriculture ascend to a higher priority, and we are turning our attention to the first rung on the ladder: Energy conservation to reduce demand and the impact of rising prices on producer-members.

The connection between water quality, energy and agriculture's role in demand reduction is clear:

1. Yes, agriculture can certainly help meet supply requirements for energy by producing corn, soybeans and other biomass, and investing in ethanol and soy biodiesel plants, but agriculture must take immediate steps to reduce agriculture's demand for energy, too.
2. Any producer that reduces commercial nitrogen use, especially anhydrous ammonia, or reduces tillage passes and soil erosion with the stated purpose of improving water quality, is also helping our country reduce its demand and reliance on fossil fuels and foreign oil.

The notion of Iowa farmer as patriot is not new, nor is the idea that farmers care about our national security. Many Iowa farmers, or their parents, sons or daughters have served, or are serving, in our nation's armed forces or in our State's National Guard. But, in an era of gas guzzling pickups and low mileage auto fleets on our nation's roads, few in this country can do what farmers can do: tackle supply AND demand simply by doing the job they do every day better and better.

That's the premise behind CEMSA: continual improvement in environmental performance. If you are enrolled in the CEMSA program, then you know that becoming a better manager and putting yourself on a path toward learning how to become more eco-efficient is going to help the environment and your bottom line. We've learned, and can demonstrate, that when CEMSA participants address nitrogen efficiencies, there are real improvements to bottom line, water quality AND energy savings. The case studies in this report illustrate how eleven producers can strengthen their bottom line and strengthen homeland security, too.

Eco-efficiency: Ecology and Economy Co-Drive Development of New Tools for Farming Profitably

Working with the first-generation software tool developed by ISA members, this report is a result of a study on the energy intensity of inputs to row crop production. Nine crop consultants and 51 producer-clients of these consultants agreed to use the software tool to look at their operations.

We acknowledge the sample size is small, and that wide generalizations are not possible with such a small set of cases. But, the findings are nonetheless significant. The study is being reported in Two Volumes as described below:

- Volume 1 presents eleven of the 51 case studies that our analysis suggests would provide illustration of key findings from the study.
- Volume 2 presents the comparative study of practices and results that are identified among the 51 cases and will feature key findings from the data.

The tools used for this project and the analysis of the raw data provide a means for producers to see how different practices might yield a given amount of savings on a case study farm. The study has also fostered consideration of what new measures of efficiency might be necessary to evaluate the productivity of modern agriculture. The tool was built to include all major production related activities, and to convert these activities, and the most common forms of energy, whether diesel, propane, or electricity into a common unit of measure to which everyone in agriculture can relate: Gallons of Diesel Fuel Equivalent per acre, or GDFE/ac, which is the primary unit of measure used within this study.

This study introduces a new measure of eco-efficiency, ENSCORE, which provides producers and crop consultants with a single index number for expressing yield per unit of energy. For generations, we have used an acre of land as the denominator in common expressions of productivity and efficiency. Row crops are often reported in terms of yield per acre, whether bushels per acre of corn, soybeans and other crops, or similar measures for forage crops (tons per acre), fiber crops (bales of cotton, etc.), or oil seeds (gallons per acre, liters per hectare, etc.) Now, the most dynamic variable on the balance sheet might very well be energy costs.

Converting all of the energy intense activities required to produce row crops and aggregating those figures into a total GDFE/ac for a particular field's crop helps calculate ENSCORE. Then, when yield, stated in bushels per acre, is divided by GDFE/ac, the net result is bushels per GDFE, or yield per unit of energy. The energy input to row crop production includes direct energy expended in terms of quantities of diesel, LP, electricity or other fuels in uses, and also includes indirect energy embedded in fertilizers, chemicals, equipment (not assessed in this study), and when known, manures. This new measure is called ENSCORE, or simply **En**ergy Score.

Case "Story" Example

This project provided lots of examples of how this project and its findings are relevant to how a farm is run. This excerpt from one of the cases written up in this volume provides an illustration of how useful an energy analysis can be for a producer.

> When I visited with Bob about the CEMSA Energy Planning and Assessment Project and asked if he would be interested in participating, he said sure. We talked about energy use in crop production and I asked Bob what his goals were for energy use on his farm.
>
> Bob's goals include:
>
> 1. Reduce unnecessary tillage trips
> 2. Increase use of GM corn to enable him to leave it in field longer to dry naturally and reduce drying costs and improve grain quality.
> 3. Consider no-tilling soybeans into corn stalks to reduce trips. This would save fuel, time and conserve soil.

4. He's not sure that he can reduce nitrogen rates much more. He's had late season stalk samples analyzed for nitrogen the past couple of years and most have come back in the optimum range. He may apply some nitrogen in the spring, though, on a couple of fields and reduce nitrogen rates in those fields by 15-20 units of nitrogen/acre.

We ran a couple of different scenarios on both corn and soybeans for Bob. We ran one corn scenario using Bob's actual tillage, fertilizer rates, etc. for one of his fields in 2006 and ran another scenario for the same field where we reduced the nitrogen rate by 15 units/acre.

We ran a soybean scenario on one of his fields – a typical field for Bob and then turned around and ran the same scenario as a no-tilled field to see how much of a difference in energy consumption the tillage reduction would make.

After I finished printing out the energy reports, I called Bob and stopped out and reviewed them with him. We looked over the corn scenarios first and Bob was amazed at how much energy was attributed to nitrogen that he applied to his corn. He was also a little surprised at the amount allocated for grain drying. We looked at the amount of energy that he could save by reducing his nitrogen application by 15 pounds/acre – about 2 gallons per acre. Bob said that he would consider applying the reduced rate to a couple of his fields in the spring – fields that are more prone to nitrogen loss. He'd heard a few reports about much higher nitrogen prices in the spring, though, so he thought that he'd probably still apply his usual rate this fall on all of his other fields.

We also talked about grain drying costs. We had scouted Bob's cornfields about 10 days ago and only found one of his fields with a significant stalk rot problem. He plans on harvesting that field as soon as it drops below 25% moisture, but since others are standing well and have very little stalk rot, he'd like to let them dry in the field until they drop to at least 20% moisture to save energy. He has two cornfields that are just as close to his local grain elevator as they are to his bin site. They are both standing well with very little stalk rot, so we talked about letting them both dry down to <17% moisture and hauling them directly to the elevator to save the expense and time involved in hauling them to his bin site, running them through the dryer, and then hauling them to the elevator.

Bob isn't really interested in no-tilling his corn, so we didn't talk much about making changes in his tillage practices.

We also went over his two soybean scenarios comparing no-tilled soybeans to his conventionally tilled soybeans. The first thing that Bob commented on was the huge difference in energy required to produce corn as compared to soybeans. Even after reducing his nitrogen rate by 15 pounds per acre, his corn consumed 36 gallons of diesel fuel. His conventional soybeans required 3.6 gallons of diesel and no-tilling soybeans saved Bob another 1.5 gallons of diesel fuel/acre.

Bob and I spent a few minutes talking about no-tilling soybeans. We both agreed that with the recent shift to more continuous corn, we had noticed a few used no-till drills at some of the local farm implement dealerships. Bob said that he and his son-in-law had talked about purchasing a used no-till drill this winter. I mentioned that another benefit would be in time management. One could be planting corn while the other could be drilling no-till soybeans at the same time. It sounded like they would definitely be in the market for a drill.

Bob appreciated seeing the results of the Energy Planning and Assessment Project and was disappointed when I took the Plan with me to the pickup. He wanted to take a closer look at it. I apologized for not making a copy and promised to bring him a copy back within a day or two.

Eleven Cases, Nineteen Key Findings (and more)

In case after case, the data clearly illustrates that shifting from conventional tillage to No-till soybeans can cut energy required to produce soybeans in half, which results in a doubling or more of a new measure of eco-efficiency, yield per unit of energy, or ENSCORE.

Each of the eleven cases selected for this volume yields one or more Key Findings. When reviewing these results, it is important to keep in mind that this is a small sample size. Each Key Finding should be followed by a more-in-depth review of the single case.

1. **Producer 2's case would suggest that:**
   - Long-cycle rotations (C-B-O-A-A-A) with nitrogen fixing crops demonstrate potential to eliminate any requirement for commercial nitrogen and thus, could require less energy than short cycle rotations with high demand for nitrogen.
   - Taking three points off of harvest moisture for corn can result in a 30% drop in energy required to produce corn and dry it to 14% for delivery.
2. **Producer 12's case would suggest that:**
   - Use of manure on corn can eliminate the need for commercial nitrogen.
   - Combining use of manure on corn with harvesting at 17% moisture instead of 19% can reduce energy use by 76% (GDFE/ac basis).
3. **Producer 15's case would suggest that:**
   - When grain drying is excluded from consideration, use of manure on corn land can reduce GDFE/ac by a whopping 85%.
4. **Producer 20's case would suggest that:**
   - Big gain: When comparing continuous corn under conventional tillage with a soybean following corn rotation that has low N-requirements and use of no-till on the corn in the cycle, over a six year period energy costs can be cut in half!
   - Small gain: In continuous corn, reducing anhydrous ammonia by 10 lbs per acre reduces the GDFE/ac requirement by 10% and increases the yield per unit of energy by nearly 12%.
5. **Producer 24's case would suggest that:**
   - Use of deep tillage on soy, such as "disk, chisel plow" can lead to a 53% increase in the energy required to produce soybeans irrespective of the yield from either practice. When yield is taken into consideration, elimination of deep tillage and greater use of No-till in soy, can improve yield per unit of energy by 44%.
6. **Producer 27's case would suggest that:**
   - All other things held constant, pulling one point off of corn moisture at harvest can reduce energy requirements on a GDFE/ac basis by 17%. This producer Reduced Harvest Moisture by 1% and saved 2.79 GDFE/ac.
   - All other things held constant, use of manure on this farm reduces GDFE/ac by 56%. This producer used manure to offset commercial fertilizers and saved 20.48 GDFE/ac.
7. **Producer 30's case would suggest that:**
   - Big gain: Shifting from tillage to No-till in soybeans can lead to a 43% reduction in the energy required to produce soybeans, and a 75% improvement in yield per unit of energy.
   - Small gain: Reducing anhydrous ammonia by 10% can lead to a 6% reduction in the energy required to produce a corn crop.

8. **Producer 33's case would suggest that:**
    - Big gain: Use of a short season corn hybrid and in-field drying to 15% moisture can reduce corn production energy requirements (GDFE/ac basis) by 33%.
    - Small gain: If you can produce soy without starter fertilizer, you can save 11% of the (GDFE/ac basis) energy required to produce soybeans.
9. **Producer 40's case would suggest that:**
    - Big gains in soy: Switching to No-till on soybeans could net a 57% decrease in energy required to produce soybeans, which is entirely attributable to the change in tillage.
    - Small gain: Moving to minimum tillage on corn and harvesting at 17% moisture nets a 31% decrease in the energy required to produce corn in this C-SB rotation.
    - Real savings in continuous corn: In this corn on corn case, all other things being equal, use of swine manure instead of anhydrous cut the energy required to produce corn by 62%.
10. **Producer 41's case would suggest that:**
    - Field conditions might dictate what is possible or feasible. Whereas one set of fields might respond well to conventional tillage and 140 lbs/acre of UAN, and yield 175 bu/ac corn, and a separate set of fields might respond well with reduced tillage and only 120 lbs/ac of UAN to produce 166.5 bu/ac corn at a slightly lower total energy cost (GDFE/ac basis, it is not clear from this analysis that the reduction in tillage and commercial N on one set of fields will work on the other set of fields. This project can stimulate thinking and practice changes based on preliminary findings, but only you can decide what is best to realize energy savings in your operations. This case discusses four decision-making levels for assessment, planning, action, monitoring and evaluation of energy conservation on your farm.
11. **Producer 43's case would suggest that:**
    - On any individual farm, when soy production practices are identical across all fields in the farming operation, then energy requirements to produce soy are more likely to be near identical from field to field, with any variation attributable to distance from the field to storage.
    - Corn energy requirements might have greater variance from field to field due to slight differences in tillage, planting, chemical/fertilizer application methods, and/or nutrient application rates.

Methodology

Data Gathering

The CEMSA program provides the context for the methods employed in this study. CEMSA participants are engaged in an annual planning cycle that requires gathering data, establishing goals, determining a baseline, evaluating alternatives and developing an action plan. In this study, data was gathered by nine (9) crop consultants who were provided with a first-generation software tool developed by a small group of crop consultants who are active in the ISA CEMSA Program. Crop consultants then met with producers and used the software tool to develop an energy plan and assessment for their operations, which included an individual data set for each of

51 producer-participants in the study. Generally, consultants and producers collaborated to input data to the tool on the following key parameters:

- Narrative farm descriptors (acreage, rotation, tillage patterns, etc.)
- Equipment inventory
- Quantitative, field-by field scenarios of recent, current or alternative practices related to the following operational parameters:

Direct Energy Inputs

- o Tillage and Planting
- o Chemical and Fertilizer Application
- o Harvest and Transport
- o Grain Drying

Indirect Energy

- o Fertilizer and Lime

Energy Costs (physical units and dollar costs at reported costs/unit respectively for

- o Diesel, Propane, and Electricity

In addition, operational parameters related to yield, harvest moisture, drying endpoint moisture were reported for each scenario.

Data chain of custody transferred copies of the data from crop consultants to the ISA Ag Energy study Project Manager, who then forwarded the raw data to the Project Research Analyst for database development, data entry and analysis.

The database was developed to integrate summary data and operational parameters for all 51 producer-participants in the study. Some variation in structure and content of case study data resulted from lack of a common protocol for use during data collection.

As a consequence:

- A few consultants developed reports that provide data on a producer's practices on all fields, yet did not model any alternative practices to see what might be improved. For this group, it was enough to simply see which aspects of the operation required lots of energy.
- Another cohort of participating consultants would provide reports on an aspect of the farm operation that was of interest to the consultant's client, for example, if they were thinking of moving to continuous corn, they might model a C-C rotation against a corn-soybean rotation.
- Another group of participating consultants used the tool to model a variety of scenarios with changes in rotation, tillage, harvest moisture and nutrient application.
- In a few cases, some producers did not report on all crops, e.g., data was only provided for corn scenarios or for soy only.

When potential discrepancies in the data were discovered, the Research Analyst notified the Project Manager, who would then request, or otherwise work with the crop consultants to address any items identified for review or clarification. Responses where then handled in the same manner as the original files. In a few cases, addressing the lack of initial clarity for field data collection would have required major rework by project participants, and a judgment was made to work with what was initially provided.

Data Analysis

Each individual producer was assigned a *Producer Number*. Each scenario reported by an individual farm operator was assigned a Data Record Number that corresponds with the sequence of data records listed in a summary sheet generated by the software tool when used by consultants with their respective clients. Data fields were established to mirror the summary table and the operational parameters used to generate GDFE/ac values.

Methodological issues and data quality

Accounting for the use of manure

Readers of the case studies presented here will note that use of manure can, in some cases, lead to significant reductions in the energy required to produce crops. This is a first-of-its-kind study. We anticipated we would see some data that affirmed common understandings like “manure reduces the need for commercial fertilizers.” We also expected that we would learn a few things, and perhaps uncover some issues that were never before given consideration. What we learned about manure has surprised us.

The software tool used to gather, calculate and analyze data for this study is a first generation tool that focused primarily on row crop production and related activities. The tool is constructed with conversion factors for the energy intensity, or energy inputs, into row crop production processes, including all field practices, grain drying, and major types of commercially available nutrients (NH3, UAN, Diammonium Phosphate, etc.). Using readily available data, the tool is constructed with measures of the energy requirements to produce commercial fertilizers, and when one of these fertilizers is chosen, the tool generates a value for the energy intensity per unit of fertilizer or per unit of nutrient. For manure, the tool returns a value of “0,” when, in fact, we know it has some value yet to be determined for swine, dairy, beef cattle, poultry and other species.

It is widely known that use of manure can offset, in whole or in part, need for commercial nutrients, and that manure testing and soil analysis can lead to significant reductions in use of commercial fertilizers. Livestock producers, and crop producers who use manure, can readily report on the energy cost and dollar cost of managing manure <u>after</u> it is produced. Surprisingly, this project revealed a need for information on the energy inputs to the production of manure.

This discovery is raising some rather significant questions. Clearly all species of animals do not convert 100% of feed into meat, milk or fiber. Some portion of input creates “product,” and the remainder is “non-product,” or manure. However, manure is increasingly being used as a source of biomass input to anaerobic digestion and other industrial processes, and cost-based activity accounting would suggest that allocating all of the energy required to produce livestock to the traditional marketable products, and NO energy allocation to production of manure, could lead to undervaluation of energy costs and dollar costs associated with manure’s use in row crop production or as an input to other industrial processes. ISA has initiated studies to address this discovery so that we can better understand the net energy of row crop production, and thus net energy of crops used for food, fuels like biodiesel and ethanol, and other products. Until further study is completed on this issue, some adjustment in these figures is likely, but as this study commenced and analysis performed and concluded for this report, the magnitude of the adjustment is unknown.

An example of this issue and its impact on the analysis reported in the cases that follow can be found in the Case for Producer 12. When using commercial nitrogen, NH3, corn production requires 34.50 GDFE/ac. When using manure, corn production requires 8.22 GDFE/ac. We believe that the 8.22 GDFE/ac figure is somewhat understated because common methods for manure accounting have heretofore not considered the energy cost of production, and thus, we could not build this energy cost into the tool used for the study. Again, we don't yet know the magnitude of the change, but further study of the energy required to produce manure could lead to a restatement of these results such that the reported reduction in energy use would be less than stated in the case study. In the case of Producer 12, where the analysis reports that "manure reduces energy use (GDFE/ac basis) by 76%," and in other cases with similar claims, knowledge gained in future research will attenuate, or dial-in, these results to a more accurate figure. From a practical perspective, the net impact on farming operations remains unchanged: use of manure can significantly offset requirements for commercial fertilizers.

This project has helped ISA discover an important area for future research so that we can, as CEMSA management principles would require, deliver continual improvement in the quality of data input to farm energy analysis and improve the quality of data outputs in future studies.

Alfalfa and Oats

The first-generation software tool does an excellent job of calibrating the energy required to produce two major crops, corn and soybeans, and this is adequate for this first-generation study. Tool developers made an effort to incorporate all of the energy intense activities associated with other crops that might be found in rotations, but time and resources constrained a complete analysis of inputs to other crops and specifications within the tool to yield a comprehensive study of alfalfa, oats, and some other crops.

For example, in the case of alfalfa, the tool is limited to reporting yield in bushels per acre, and alfalfa hay is often reported in tons or other measures. Removal of hay from the field also presented problems during tool development due to the wide variation in bale form and size, and variability in the equipment used to haul hay from the field to storage. Similarly, with oats, tool development stopped short of developing a full accounting of oat straw and oat yields. With but one exception, energy inputs to oats and alfalfa and measures like GDFE/ac and other findings associated with alfalfa and oats are not presented for discussion in this report.

Selection of data from the database to model outcomes on a case study farm

Data submitted from nine (9) participating crop consultants and fifty-one (51) producers presented unique challenges to database development and analysis. Some of the issues that impact cases selected for this Volume I, and for presentation within the case of high-cost versus low-cost scenarios on the farm include:

a. As a first-of-its kind study, the software tool was released to consultants for work with producers on a "see what materializes basis," and without rigid instructions for its use.
b. Variation between and within the farm operations. Some cases provided data on two fields, and others provided data on as many as 18 fields. No effort is made to gather data or attempt to control variables for soil types, hybrid selection or other key agronomic factors.
c. For some cases, scenarios were run to analyze past practices, whereas other cases indicate that some modeling was done on current, and/or future practices.

The analysis undertaken for this report seeks to establish or identify for a particular farm the high-energy intensity practices and, alternatively, low energy intensity practices. While acknowledging that soil tests, stalk tests and other parameters can influence the scenario parameters used in this project to generate outcomes developed for analysis in the database used for this study, this write up used the following guidelines to select data for this report:

1. When data clearly represents the outcome of a rotation on a particular field, the values reported for activities on one field are selected for illustration of high cost, or low cost or both.
2. When data provided is not so clear as to be reporting on one field, then the data for that producer is analyzed to identify a set of high cost practices, and a set of low cost practices. This may result in a Baseline Scenario that is constructed from a corn scenario on one field, but a soy scenario on another field. A similar approach/outcome is used to develop the Alternative Practices Scenario.

This second guideline item in the above list is used, if necessary, to focus attention on a practice that stands out, whether a baseline scenario practice that could be improved, or an alternative practice on one field that when applied to all the other fields, might lead to energy savings. But, it is possible that the modeling of baseline or alternative practices under the second item in the above list could result in a baseline or alternative practice scenario that would not, or could not, due to soil or stalk sampling or other parameters, be realized across the entire operation.

Explanation of the Report Format

CASE STUDY #

Producer
Crops & Rotation Patterns
Primary tillage
Livestock on farm
Manure utilized on this farm

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac =
Corn ENSCORE =
Soy GDFE/ac =
Soy ENSCORE =
Six-Year Rotation Energy Cost GDFE/ac

The identity of project participants is	*The data summarized in the Green Zone box*

confidential. All participants are identified by number. When reported in case materials used to build the analytical database, data is presented to describe crops and rotation patterns, primary tillage patterns, the presence or absence of livestock, and whether manure is reported to be used on the farm.	*represents a summary of the Best Plan Outcome on the case study farm. GDFE/ac is reported, followed by ENSCORE, or yield per unit of energy. Six year rotation is used to put all rotation patterns, whether, for example, C-SB for two years, or C-C-SB for three years, or in one case a six year C-SB-O-A-A-A rotation, on equal footing.*

This Case Study Volume I reports on individual cases, and the discussion is focused on comparison of actual or modeled practices on a particular farm and within the case being presented. Due to variability in farm practices, yields and other data, drawing comparison between GDFE/ac between two cases or among three or more cases is discouraged. ENSCORE addresses some of the data variance by dividing yield in bushels per acre by the Total GDFE/ac generated by the software, and this would allow some case-to-case comparison within this Volume I. Volume II presents a more in-depth comparative analysis of the case study findings.

Key Findings

One to three key findings from the case are summarized.

Baseline Scenario

Baseline Scenario is typically a record of current or most recent operations, unless the producer is already operating in the "GREEN ZONE," in which case, the baseline scenario is developed to reflect abandoned high energy cost practices. In either case, the baseline scenario is used as the high energy cost scenario.

Crop	**GDFE/ac**	**Key Parameters N rates/ac** (or some other parameter)	**Yield**	**ENSCORE**
Corn				
Soybean				

A Narrative Paragraph that describes the baseline scenario follows each baseline table.

Alternative Practices Scenario(s)

Alternative Practices Scenario typically represents a modeling of "GREEN ZONE" practices that yield energy and cost savings from changes in any or all of the following: rotation, tillage, nutrient application type, nutrient application rates, harvest moisture %, grain drying end-point %.

Crop	**GDFE/ac**	**Key Parameters N rates/ac** (or some other parameter)	**Yield**	**ENSCORE**
Corn				
Soybean				

A Narrative Paragraph that describes the Alternative Practices Scenario(s) follows each baseline table.

Results/Findings/Discussion – The eleven cases

CASE STUDY 1 – PRODUCER 2

Producer	2
Crops & Rotation Patterns	C-B-O-A-A-A, and C-SB
Primary Tillage	No-till
Livestock on farm	No
Manure utilized on this farm	No

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac = 20.45
Corn ENSCORE = 8.31

Soy GDFE/ac = 1.63
Soy ENSCORE = 33.74

Six-Year Rotation Energy Cost
57.61 GDFE/ac

Key Findings
This single case would suggest that:

1. Long-cycle rotations with nitrogen fixing crops demonstrate potential to eliminate any requirement for commercial nitrogen and thus, could require less energy than short cycle rotations with high demand for nitrogen.
2. Taking three points off of harvest moisture for corn can result in a 30% drop in energy required to produce corn and dry it to 14% for delivery.

Baseline Scenario Corn-Soybean rotation

Crop	GDFE/ac	Key Parameters N rates/ac & Harvest Moisture	Yield	ENSCORE
Corn	49.58	120 – UAN 21% moisture	170	3.43
Soybean	2.18	None	55	25.23

This producer uses a Corn-Soybean rotation. The use of No-till, starter fertilizer, 120 lbs of side-dressed UAN, and harvesting at 21% contribute to a demand for 49.58 GDFE/ac to produce 170-bu/ac corn. No-till soy required 2.18 GDFE/ac. Running this rotation and replicating these practices three times over a six year period would require 155.28 GDFE/ac.

Alternative Practices Scenario(s) Corn – Soybeans – Oats – Alfalfa – Alfalfa – Alfalfa

Crop	GDFE/ac	Key Parameters N rates/ac & Harvest Moisture	Yield	ENSCORE
Corn	29.43	No N; 20% moisture	170	5.78

Soybean	1.63	None	55	33.74

This producer also has a six-year rotation of Corn – Soybeans – Oats – Alfalfa – Alfalfa – Alfalfa on some fields. In this rotation, even with the use of a moldboard plow and harvest at 20% moisture, 170-bu/ac corn only requires 29.43 GDFE/ac, a 41% reduction in energy use/ac for the corn in the rotation. After including the energy cost for the Oats and Alfalfa over the remaining four years of this rotation result in a low Six Year Rotation Energy Cost of 66.59 GDFE/ac.[2]

Use of the six-year rotation results in a savings of roughly 88 GDFE/ac compared to the energy required to farm this land in a corn-soybean rotation over six years. With only one year of corn and one year of soy in the rotation, over six years the revenue performance on this acreage would predictably be lower than the revenue from acreage in a corn-soybean rotation. But, this case illustrates how a longer rotation can lead to 100% reduction in purchase of commercial Nitrogen.

On this farm, additional gains in energy savings could be realized by harvesting corn in the C-B-O-A-A-A rotation at 17% moisture instead of 20%, for a savings of 9 additional GDFE/ac, or nearly a 30% drop in energy use by dropping three points off of the moisture at harvest. At 170 bu/ac, the ENSCORE, or yield per unit of energy improves by 44% from 5.78 to 8.31

Crop	**GDFE/ac**	**Key Parameters N rates/ac & Harvest Moisture**	**Yield**	**ENSCORE**
Corn	20.45	No N 17% moisture	170	8.31
Soybean	1.63	None	55	33.74

Taking the additional step of reducing harvest moisture to 17% would result in a total six-year rotation energy cost of only 57.61 GDFE/ac, an additional 13% gain in energy savings over the entire six year rotation, and a total percentage improvement of 63% when compared to the baseline scenario C-SB rotation that requires 155.28 GDFE/ac over six years.

This producer is already saving 88 GDFE/ac by adoption of the six-year crop rotation instead of planting these acres in a C-SB rotation for six years. Multiplied by the 175 acres in the rotation, total fuel savings would be 15,400 GDFE over six years.

[2] See the Methods section of this report and the discussion about measuring and reporting on energy required to produce alfalfa and oats.

CASE STUDY 2 – PRODUCER 12

Producer	12
Crops & Rotation Patterns	C-SB
Primary tillage	No-till; Min-till
Livestock on farm	Swine
Manure utilized on this farm	Swine

Best Plan Outcome on This Farm

GREEN ZONE Corn GDFE/ac = 8.22 Corn ENSCORE = 21.90
Soy GDFE/ac = 2.61 Soy ENSCORE = 22.99
Six-Year Rotation Energy Cost 32.49 GDFE/ac

Key Findings

This single case would suggest that:

1. Use of manure on corn can eliminate the need for commercial nitrogen.
2. Combining use of manure on corn with harvesting at 17% moisture instead of 19% can reduce energy use by 76% (GDFE/ac basis).
3. When an operation that produces 180 bu/ac of corn using 120 lbs/ac of anhydrous and harvests at 19% moisture is compared against a switch to manure for nutrients and harvesting at 17%, the yield per unit of energy improves by a factor of 4.19, or over 400%!

Baseline Scenario – commercial nitrogen and corn harvest at 19% moisture

Crop	GDFE/ac	Key Parameters N rates/ac & Harvest Moisture	Yield	ENSCORE
Corn	34.50	120 – NH3 19% moisture	180	5.22
Soybean	2.61	None	60	22.99

This producer has a Corn-Soybean rotation. The use of No-till on corn, 120 lbs of anhydrous ammonia, and harvesting at 19% contribute to a demand for 34.50 GDFE/ac to produce 180-bu/ac corn. Soy with minimum tillage (row crop cultivator) required 2.61 GDFE/ac. Running this rotation and replicating these practices three times over a six year period would require 111.33 GDFE/ac.

In the baseline scenario, ENSCORE analysis reveals that corn yield per unit of energy (5.22) is a mere 23% of the ENSCORE for soy (22.99). Stated on a GDFE/ac basis, in this baseline scenario, corn requires 13 times as much energy per acre as soybeans.

Alternative Practices Scenario(s) – manure nitrogen and corn harvest at 17% moisture

Crop	GDFE/ac	Key Parameters N rates/ac & Harvest Moisture	Yield	ENSCORE
Corn	8.22	120 – Manure 17% moisture	180	21.90

Soybean	2.61	None	60	22.99

At 180 bu/acre, use of manure for all crop nutrients and harvesting at reduced moisture (17%) would reduce energy requirements per acre by a stunning 76%, and reduce energy requirements for corn to where in this alternative scenario, corn would only require 3 times as much energy per acre as soybeans. Use of manure has a significant impact on ENSCORE, raising the performance measure of yield per unit of energy to 21.90, a level that results in a nearly identical energy requirement as soybeans (22.99). Running this rotation over a six-year period would only require 32.49 GDFE/ac.

CASE STUDY 3 – PRODUCER 15

Producer	15
Crops & Rotation Patterns	Corn
Primary tillage	Conventional
Livestock on farm	Dairy
Manure utilized on this farm	Yes

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac = 5.29
Corn ENSCORE = 34.03

Soy GDFE/ac = none
Soy ENSCORE = none

Six-Year Rotation Energy Cost
29.67 GDFE/ac **

Key Findings

This single case would suggest that:

1. When grain drying is excluded from consideration, use of manure on corn land can reduce GDFE/ac by a whopping 85%.
2. Stated another way, the same scenario has the effect of improving yield per unit of energy for corn production on this farm by 668%.

** The six-year rotation Energy Cost reported here includes Alfalfa instead of soybeans.

Baseline Scenario – commercial nitrogen, no grain drying

Crop	**GDFE/ac**	**Key Parameters N rates/ac**	**Yield**	**ENSCORE**
Corn	35.39	185 - NH3	180	5.09
Alfalfa w/ fert	6.06	No N	Not reported	Incalculable

This dairy producer did not report soy planting for the project year. But, the case still provides insight derived from analysis of an operation that could use conventional tillage and commercial nitrogen to produce 180 bu/ac from corn on corn for grain or silage, but does not need to use any at all because manure is available for use on the dairy's cropland. Even without drying, corn on corn (for grain) with 185 lbs/ac of anhydrous can require 35.39 GDFE/ac. In this baseline scenario, yield per unit of energy is only 5.09. While not requiring any energy for grain drying, corn silage has other energy requirements associated with storing silage that can add an additional 3 GDFE/ac to the total GDFE/ac required to produce corn.

Alternative Practices Scenario(s) – manure nitrogen, no grain drying

Crop	**GDFE/ac**	**Key Parameters N rates/ac**	**Yield**	**ENSCORE**
Corn	5.29	185 - Manure	180	34.03
Alfalfa w/o fert	4.06	None	Not reported	Incalculable

Use of manure on this producer's corn land eliminates the need for commercial nitrogen, and reduces GDFE/ac requirements to produce corn from 35.39 GDFE/ac to 5.29 GDFE/ac, a whopping 85% reduction in GDFE/ac.

CASE STUDY 4 – PRODUCER

Producer	20
Crops & Rotation Patterns	C-C and C-SB
Primary tillage	Conventional
Livestock on farm	No
Manure utilized on this farm	No

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac = 26.85
Corn ENSCORE = 6.89

Soy GDFE/ac = 5.63
Soy ENSCORE = 9.77

Six-Year Rotation Energy Cost
97.44 GDFE/ac

Key Findings

This single case would suggest that:

1. Big gain: When comparing continuous corn under conventional tillage with a soybean following corn rotation that has low N-requirements and use of no-till on the corn in the cycle, over a six year period energy costs can be cut in half!
2. Small gain: In continuous corn, reducing anhydrous ammonia by 10 lbs per acre reduces the GDFE/ac requirement by 10% and increases the yield per unit of energy by nearly 12%.

Baseline Scenario 1

Crop	GDFE/ac	Key Parameters N rates/ac	Yield	ENSCORE
Corn (C-C)	36.07	145 - NH3	185	5.13

This producer has some acreage in continuous corn under conventional tillage that is harvested at 17% moisture. Over six years, this system would require 216.42 GDFE/ac.

Alternative Practices Scenario 1

Crop	GDFE/ac	Key Parameters N rates/ac	Yield	ENSCORE
Corn (C-C)	32.30	125 - NH3	185	5.73

In this continuous corn scenario, reducing anhydrous ammonia by 20 lbs/ac reduces the GDFE/ac requirement by 10% and increases the yield per unit of energy by nearly 12%. Over six years, this system would require 193.8 GDFE/ac, netting a savings of just 22.62 GDFE/ac over the entire six years.

Baseline Scenario 2

Crop	GDFE/ac	Key Parameters N rates/ac	Yield	ENSCORE
Corn	32.56	135 – NH3	185	5.68
Soybean	6.28	None	55	8.76

In another field where soybeans following corn is the common rotation, the use of minimal tillage on corn can result in a requirement of 32.56 GDFE/ac. In a nearby corn-follows-soybeans field, where deep tillage is used to prepare the field for the soybean crop, tillage practices and P & K applications result in a soybean crop that requires 6.28 GDFE/ac, one of the highest energy requirements for soybean production seen among all 51 cases.

Alternative Practices Scenario 2

Crop	GDFE/ac	Key Parameters N rates/ac	Yield	ENSCORE
Corn	26.85	100 – NH3	185	6.89
Soybean	5.63	None	55	9.77

No tilling corn, and reducing nitrogen by 26% can result in a requirement of 26.85 GDFE/ac, a savings of nearly 18%. Where soybeans following corn is the common rotation, eliminating one tillage pass in conventionally tilled soybeans, shaves nearly 12% off of the GDFE/ac required to produce soybeans in this rotation. A comparison of this approach to the practices on the continuous corn land suggests that GDFE/ac requirements for a six-year rotation could be cut in half!

CASE STUDY 5 – PRODUCER 24

Producer	24
Crops & Rotation Patterns	Corn after soybeans and/or alfalfa
Primary tillage	Conservation & No-till
Livestock on farm	Cattle, hogs in open lots
Manure utilized on this farm	Yes

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac = 8.15
Corn ENSCORE = 18.77

Soy GDFE/ac = 2.63
Soy ENSCORE = 20.90

Six-Year Rotation Energy Cost
32.34 GDFE/ac

Key Findings
This single case would suggest that:

1. Use of deep tillage on soy, such as "disk, chisel plow" can lead to a 53% increase in the energy required to produce soybeans irrespective of yield. When yield is taken into consideration, elimination of deep tillage and greater use of No-till in soy, can improve yield per unit of energy by 44%.
2. Late spring nitrogen soil tests can be an effective tool to reduce energy and nutrient inputs, and improve timing of applications so that the crop gets what it needs when it needs it.
3. Manure from open lots will often lose N value to volatization. Manure management strategies might be helpful to preserve N, and thus further offset the need to use composite fertilizers.

Baseline Scenario

Crop	**GDFE/ac**	**Key Parameters N rates/ac Tillage**	**Yield**	**ENSCORE**
Corn	33.85	111 – UAN + 80 lbs 10-34-0 Conventional Tillage	163	4.82
Soybean	4.03	None Conventional Tillage	47	11.66

This producer is "using the late spring nitrogen soil test to verify nitrogen availability at the 4-5 leaf corn stage. He already uses . . . a minimal amount of N for his rotations. Zero N on alfalfa fields and only (sic 80)/90 lbs. pre-plant on both corn following soybeans and corn on corn. He side-dresses additional N if the soil test results show the need for it. The last 2 years we have put no extra N on either rotation." Thus, the baseline rotation represents the high energy cost scenario for a year when the field is cultivated, UAN is needed on corn, and harvest was at 17% moisture. The soy scenario reported here represents a field where deep tillage is practiced on soy, and for a year that is not encumbered by energy costs associated with application of Potash that would be available across multiple rotation cycles. This scenario would cost 113.64 GDFE/ac over six years of a Corn-Soybean Rotation.

Alternative Practices Scenario(s)

Crop	GDFE/ac	Key Parameters N rates/ac Tillage	Yield	ENSCORE
Corn	8.15	40 – Manure + 80 lbs 10-34-0 Minimum Till	153	18.77
Soybean	2.63	None Minimum Till	56	20.90

This case provides yet another example that use of manure and harvesting at low moisture can lead to significant reductions in energy required to produce corn. The alternative practices captured in this alternative scenario include tillage limited to use of a field conditioner, substitution of manure for a portion of crop nutrient needs, and a reduction in harvest moisture from 17% to 16%. Altogether, these alternative practices result in a 76% reduction in GDFE/ac to produce corn. Data used to develop this alternative practice scenario is not from the same fields used to model the baseline scenario, so it is unknown if the low energy alternative practices scenario is the appropriate strategy across the enterprise. Nevertheless, while soil and stalk sampling might indicate some adjustments in field-specific recommendations, in general, the benefits of manure use and harvesting at lower moisture are likely to lead to energy and cost savings. This scenario would require only 32.34 GDFE/ac over six years of a Corn-Soybean Rotation.

Case Study 6 – Producer 27

Producer	27
Crops & Rotation Patterns	C-SB
Primary tillage	No-till
Livestock on farm	Swine
Manure utilized on this farm	Yes

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac = 12.98 Corn ENSCORE = 16.18
Soy GDFE/ac = 1.92 Soy ENSCORE = 27.08
Six-Year Rotation Energy Cost 44.70 GDFE/ac

Key Findings

This single case would suggest that:

1. All other things held constant, use of manure on this farm reduces GDFE/ac by 56%.
2. All other things held constant, pulling one point off of corn moisture at harvest can reduce energy requirements on a GDFE/ac basis by 17%.

Baseline Scenario

Crop	GDFE/ac	Key Parameters N rates/ac	Yield	ENSCORE
Corn	36.27	130 – NH3	210	5.79
Soybean	1.92	None	52	27.08

The crop consultant working with this producer was careful to use the tool to illustrate how much energy this producer is already saving, and used the tool to illustrate the energy savings that would be attributable to manure versus those savings that would be attributable to reduced moisture at harvest. This producer already uses manure, so the baseline scenario simply presents a picture of how much energy this operation could use if they ran the farm with a reliance on commercial nutrients.

On this farm, producing 210-bu/ac corn in a corn-soybean rotation under No-till would require 130 lbs/ac of anhydrous ammonia. This producer typically harvests at 19% moisture, and dries to 14.5% moisture, and has to haul the crop from this particular field just 1.75 miles. All of this adds up to a baseline scenario for corn that demands 36.27 GDFE/ac. The No-till soy scenario on this farm is illustrative of an actual practice. This producer’s soy scenarios are within a tight range of 1.88 to 2.38 GDFE/ac; the range of values represent additional GDFE/ac for some fields that are a bit more distant and require a little more diesel for transport. The scenario requiring 1.92 GDFE/ac is chosen because it is in the same field as the baseline and first of the alternative scenarios presented below. If this C-SB rotation scenario was run for six years, the Six Year Rotation Energy Cost would require 114.57 GDFE/ac.

A comparison of the baseline scenario against the actual practice reported in the first of two alternative practices below illustrates that this producer is already using energy saving techniques to produce corn and soybeans.

Alternative Practices Scenario(s)

Crop	GDFE/ac	Key Parameters N rates/ac	Yield	ENSCORE
Corn	15.79	126 - Manure	210	13.30

Soybean	1.92	None	52	27.08

As seen by this first scenario of alternative practices, use of manure reduces GDFE/ac for corn from 36.27 to 15.79, or a 56% reduction in GDFE/ac solely attributable to use of manure. This producer is already pocketing these savings. This alternative scenario, like the baseline scenario, has corn harvested at 19% moisture, and further savings are possible on this farm.

Crop	**GDFE/ac**	**Key Parameters N rates/ac**	**Yield**	**ENSCORE**
Corn	12.98	126 - Manure	210	16.18
Soybean	1.92	None	52	27.08

In this second scenario of alternative practices, this producer could shave an additional 2.81 GDFE/ac, or nearly 6% more, off of the energy cost of corn production simply by reducing harvest moisture by 1% to 18%. It should be noted that this second alternative practices scenario is from a field that has a transport distance that is ¾ of a mile less than either the baseline scenario, or the first alternative scenario, and this may account for a small fraction of the additional 6% of energy savings indicated here. With a dry fall and good timing, this producer might be able to harvest at 17% or better, but with the scale of the operation and equipment demand, modeling this scenario at 18% provides a reasonable and conservative estimate of potential energy savings.

If use of manure is combined with harvesting at reduced moisture, a total energy reduction of 64% off of the long-ago abandoned baseline scenario is within reach. When taking yield into consideration, producing 52 bu/ac soybeans result in an ENSCORE, or yield per unit of energy, for soy production on this farm that ranges from 21.85 to 27.66, with the variance mostly attributable to differences in transport mileage off of fields of varying distance from storage. In corn, yield per unit of energy is improved by a factor of 2.79, or 279%.

No-till in Soy, No-till in corn, manure use, and low moisture harvest can really add up.

CASE STUDY 7 – PRODUCER 30

Producer	30
Crops & Rotation Patterns	C-SB
Primary tillage	No-till
Livestock on farm	No
Manure utilized on this farm	No

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac = 36.03
Corn ENSCORE = 5.13

Soy GDFE/ac = 2.06
Soy ENSCORE = 26.76

Six-Year Rotation Energy Cost
114.26 GDFE/ac

Key Findings

This single case would suggest that:

1. Big gain: Shifting from tillage to No-till in soybeans can lead to a 43% reduction in the energy required to produce soybeans, and a 75% improvement in yield per unit of energy.
2. Small gain: Reducing anhydrous ammonia by 10% can lead to a 6% reduction in the energy required to produce a corn crop.

Baseline Scenario

Crop	**GDFE/ac**	**Key Parameters N rates/ac Tillage**	**Yield**	**ENSCORE**
Corn	38.37	145 – NH3 Conventional	185	4.82
Soybean	3.61	None Conventional	55	15.26

On corn land, field cultivation, two trips across the field to spray pesticides, an application of 145 lbs/ac of ammonia, 92 lbs/ac of diammonium phosphate, 150 lbs/ac of phosphate and harvesting at 18% moisture to dry down to 14% . . . it all adds up to a requirement for 38.37 GDFE/ac. Taking the 185 bu/ac yield into account, the baseline yield per unit of energy on this farm for corn is 4.82.

Use of a chisel plow and field conditioner contribute to a demand for 3.61 GDFE/ac to produce soybeans. With a respectable yield of 55 bu/ac, the yield per unit of energy to produce soybeans on this farm is 15.26.

Working this two-year corn and soybean rotation over six years would require 125.93 GDFE/ac

Alternative Practices Scenario(s)

Crop	**GDFE/ac**	**Key Parameters N rates/ac Tillage**	**Yield**	**ENSCORE**
Corn	36.03	130 – NH3 Conventional	185	5.13
Soybean	2.06	None No-Till	55	26.76

The alternative practices scenario developed for this producer illustrates that a 10% reduction in NH3, reduces the GDFE/ac required to produce 185 bu corn by approximately 6%. With yield and other factors held constant, yield per unit of energy increases by 6%, too.

Shifting from tillage in soy to No-till has a greater effect, on a percentage basis, reducing GDFE/ac from 3.61 to 2.06, or a 43% reduction in GDFE/ac and a 75% improvement in ENSCORE yield per unit of energy.

Working this two-year corn – soybean rotation over six years would require 114.26 GDFE/ac, a savings of 9.3% over six years compared to the energy required under the baseline scenario. This case highlights that a 10% reduction in energy intense anhydrous does not, by itself, lead to a 10% energy savings across the board. But, when a shift to No-till soybeans is combined with a 10% reduction in the rate for anhydrous, a producer can realize a net gain of 10% in energy savings. This producer might realize additional savings, if possible, by harvesting corn at 17% instead of 18%.

CASE STUDY 8 – PRODUCER 33

Producer	33
Crops & Rotation Patterns	C-SB
Primary tillage	No-till
Livestock on farm	No
Manure utilized on this farm	Yes

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac = 18.52
Corn ENSCORE = 9.72

Soy GDFE/ac = 2.18
Soy ENSCORE = 22.94

Six-Year Rotation Energy Cost
62.10 GDFE/ac

Key Findings

This single case would suggest that:

1. Big gain: Use of a short season corn hybrid and in-field drying to 15% moisture can reduce corn production energy requirements (GDFE/ac basis) by 33%.
2. Small gain: If you can produce soy without starter fertilizer, you can save 11% of the (GDFE/ac basis) energy required to produce soybeans.

Baseline Scenario

Crop	**GDFE/ac**	**Key Parameters N rates/ac Harvest Moisture**	**Yield**	**ENSCORE**
Corn	27.76	100 lbs – Manure +77 lbs N/ac 28% 19% Moisture	180	6.48
Soybean	2.45	3-18-18 @33lb/ac	50	20.41

According to the crop consultant's report, "Manure is the primary source of nutrients for this farm. Commercial nitrogen is added on corn production fields when indicated by spring nitrate tests."

This producer's baseline corn scenario looks at the grain drying aspect of the energy requirements to produce corn. The baseline soy scenario compares use of starter fertilizer against an alternative scenario without starter fertilizer.

This producer operates a No-till C-SB rotation with full season corn, which is often harvested at 19% moisture. All other things being equal, how would energy requirements change with use of a shorter season corn hybrid that might permit harvesting corn at 15% moisture?

Working this two-year corn – soybean rotation over six years would require 90.63 GDFE/ac.

Alternative Practices Scenario(s)

Crop	**GDFE/ac**	**Key Parameters N rates/ac Harvest Moisture**	**Yield**	**ENSCORE**
Corn	18.52	100 lbs – Manure	180	9.72

		+ 77 lbs N/ac 28% 15% Moisture		
Soybean	2.18	None	50	22.94

Use of a short season hybrid and having a dry year that allows in-field drying to 15% moisture would reduce corn production energy requirements (GDFE/ac basis) by 33% from 27.76 GDFE/ac to 18.52 GDFE/ac. Use of a short-season hybrid and harvesting 180 bu/ac at 15% moisture can improve ENSCORE, or yield per unit of energy, by 50%.

In a year when starter fertilizer is removed from the No-till soy plan, soy production would require 11% less energy, 2.18 GDFE/ac instead of 2.45 GDFE/ac.

Working this two-year corn – soybean rotation over six years would require 62.10 GDFE/ac, a savings of 28.53 GDFE/ac, or 31%

CASE STUDY 9 – PRODUCER 40

Producer	40
Crops & Rotation Patterns	C-SB & C-C
Primary tillage	Minimum Till
Livestock on farm	Swine
Manure utilized on this farm	Yes

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac = 14.33
Corn ENSCORE = 12.56

Soy GDFE/ac = 1.88
Soy ENSCORE = 29.26

Six-Year Rotation Energy Cost
48.63 GDFE/ac

Key Findings

This single case would suggest that:

1. Big gains in soy: Switching to No-till on soybeans could net a 57% decrease in energy required to produce soybeans, which is entirely attributable to the change in tillage.
2. Small gain: Moving to minimum tillage on corn and harvesting at 17% moisture nets a 31% decrease in the energy required to produce corn in this C-SB rotation.
3. Real savings in continuous corn: In this corn on corn case, all other things being equal, use of swine manure instead of anhydrous cut the energy required to produce corn by 62%.

Baseline Scenario

Crop	**GDFE/ac**	**Key Parameters N rates/ac Tillage**	**Yield**	**ENSCORE**
Corn	20.65	150 – Manure + 100 lbs/ac 28% Conventional Tillage	180	8.72
Soybean	4.33	None Conventional Tillage	55	12.70

For this producer, the baseline scenario for corn and soy includes use of subsoiler/ripper on both crops. Swine manure meets most of the nitrogen needs in fields planted in a corn-soybean rotation or in continuous corn. Even with use of 100 lbs/ac of 28% nitrogen and harvesting at 19% moisture, this producer only requires 20.65 GDFE/ac to produce 180-bu/ac corn in the corn-soybean rotation. Working this two-year corn – soybean rotation over six years would require almost 75 GDFE/ac. Is it possible that even greater energy savings be realized?

Alternative Practices Scenario(s)

Crop	**GDFE/ac**	**Key Parameters N rates/ac Tillage**	**Yield**	**ENSCORE**
Corn	14.33	150 – Manure + 100 lbs/ac 28% Minimum Till	180	12.56
Soybean	1.88	None	55	29.26

		No-Till		

Moving to minimum tillage on corn and harvesting at 17% moisture nets a 31% decrease in the energy required to produce corn in this C-SB rotation. Switching to No-till on soybeans nets a 57% decrease in energy required to produce soybeans, which is entirely attributable to the change in tillage. Similar improvements are seen in yield per unit of energy, which in corn improves by 44%, and in soy, a gain of 130% is realized.

When energy savings for both crops in the rotation are combined, working this two-year corn – soybean rotation over six years would require only 48.63 GDFE/ac, a savings of more than 26 GDFE/ac over six years, or 35%.

This producer also has some acreage in continuous corn that benefits from swine manure that reduces the amount of commercial fertilizers that can often impose a high cost on corn on corn rotations. When the crop consultant and producer sat down to work through various scenarios for this project, they were curious to learn just how much energy they were already saving by avoiding the use of anhydrous ammonia. The scenario depicted below provides some valuable lessons.

Crop	**GDFE/ac**	**Key Parameters Nitrogen Source**	**Yield**	**ENSCORE**
Corn-Corn – Commercial Fertilizers	41.98	160 – NH3 + 100 lbs/ac 28%	180	4.29
Corn-Corn – Manure	16.03	180 – Manure + 100 lbs/ac 28%	180	11.23

The use of manure in this rotation, supplemented by 100lbs of 28% nitrogen, and harvesting at 17% moisture, results in a total of only 16 GDFE/ac. All other things being equal, if this producer had to use anhydrous ammonia instead of swine manure, the energy required to produce corn on corn would increase by 162%, more than doubling the total to nearly 42 GDFE/ac, and improving yield per unit of energy by 162%, too! Use of swine manure is already saving this producer almost 26 GDFE/ac, or 62% of the energy that would be required to produce this crop with anhydrous.

CASE STUDY 10 – PRODUCER 41

Producer	41
Crops & Rotation Patterns	C-SB
Primary tillage	Conventional
Livestock on farm	No
Manure utilized on this farm	No

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac = 25.17 Corn ENSCORE = 6.62
Soy GDFE/ac = 2.78 Soy ENSCORE = 19.42
Six-Year Rotation Energy Cost 83.85 GDFE/ac

Key Findings

This single case would suggest that:

1. Field conditions might dictate what is possible or feasible. Whereas one set of fields might respond well to conventional tillage and 140 lbs/acre of UAN, and yield 175 bu/ac corn, and a separate set of fields might respond well with reduced tillage and only 120 lbs/ac of UAN to produce 166.5 bu/ac corn at a slightly lower total energy cost (GDFE/ac basis) it is not clear from this analysis that the reduction in tillage and commercial N on one set of fields will work on the other set of fields. This project can stimulate thinking and practice changes based on preliminary findings, but only you can decide what is best to realize energy savings in your operations.
2. If everything else is held equal in soy production, a 15% difference in yield between two fields will have a corresponding effect on the ENSCORE measure of eco-efficiency, yield per unit of energy. The data provided or this study does not provide a clear picture of what might foster the 15% difference, but any number of factors including hybrid, soil type and quality, soil moisture, pest pressure, chemical effectiveness and other parameters could explain the higher productivity of one set of fields when compared to a field with identical practices.

Baseline Scenario

Crop	**GDFE/ac**	**Key Parameters N rates/ac**	**Yield**	**ENSCORE**
Corn	30.75	140 – UAN	175	5.69
Soybean	2.78	None	47	16.91

The data provided by the crop consultant for this case study did not model alternative practices, so the baseline scenario looks at the data for year two of a corn-soybean rotation on two fields where soybeans are planted in the North field and corn is planted in the South field. Similarly, the alternative scenario looks at data for the second year production, but on a different plat of land that has soybeans in the East field and corn in the West field. In both scenarios, the data is treated as if the rotation simply reverses the planting in year one of the rotation, and that the combined data from both fields represents, or best approximates, energy required over the two-year rotation. For this case, the contrast is not so much between a high energy cost scenario versus a low energy cost scenario as it is a contrast between activities on one set of fields versus another set. As such, it is a contrast, and not a fair comparison as soil conditions and other factors could dictate or otherwise account for the difference in practices between the four parcels of land.

For corn, a subsoiler/ripper and field cultivation is used on corn in the baseline scenario, but on the other plats of land used for the alternative scenario, the subsoiler/ripper is not used and the only tillage is field cultivation. The baseline scenario includes 140 lbs UAN/ac, but the plat of land used for the alternative scenario below only received 120 lbs UAN/ac.

For soy, tillage is the same for both scenarios: tandem disking of corn stalks and field cultivation.

This producer has had good luck with weather and in-field dry down of corn, and did not report any grain drying for the project year. Conventional tillage and 140 lbs/ac of UAN then account for the major energy inputs to corn, which in the baseline scenario required nearly 31 GDFE/ac. If the two fields used for the baseline scenario are representative of a two-year corn-soybean rotation, then working this two-year corn – soybean rotation over six years would require 100.59 GDFE/ac.

Alternative Practices Scenario(s)

Crop	GDFE/ac	Key Parameters N rates/ac	Yield	ENSCORE
Corn	25.17	120 – UAN	166.5	6.62
Soybean	2.78	None	54	19.42

It's not uncommon that with similar practices, one field performs differently than another field. While this producer elected to not use the subsoiler ripper on this farm and to reduce UAN by 20 lbs/ac, other variables could impact these fields that might account for the 5% difference in yield between the two fields. If the two fields used for the baseline scenario are representative of a two year corn-soybean rotation, then working this two-year corn – soybean rotation over six years would require only 83.85 GDFE/ac, a difference of nearly 17 GDFE/ac over six years, or nearly 17%. Some additional information is required to determine why one field requires more tillage than another and whether the reduced tillage on one field would be an effective strategy on the other field.

When considering energy conservation on a row crop farm, there are four decision-making levels for assessment, planning, action, monitoring and evaluation.

- Whole Farm: Farmstead lighting; HVAC systems for home or shop; energy efficient appliances, tools and equipment. Make decisions here and reduce farm energy overhead costs.
- Processing Operations: Grain drying and handling. Make decisions here that impact energy efficiency for all acreage with crops that need drying.
- Materials: commercial fertilizer vs. manure, or choice of types of commercial fertilizer. Make decisions here with potential to impact energy efficiency for all crops and fields.
- Field-level Cropping: Hybrid selection; tillage patterns; nutrient type and application rates; pest pressure/treatment; harvest moisture.

As this case and Case Study 11 (Producer 43) illustrate, when it comes to improving the energy efficiency of corn or bean production, energy efficiency issues need to be addressed on a field-by-field basis.

CASE STUDY 11 – PRODUCER 43

Producer	43
Crops & Rotation Patterns	C-SB
Primary tillage	No-till soy Minimum Till corn
Livestock on farm	No
Manure utilized on this farm	No

Best Plan Outcome on This Farm

GREEN ZONE
Corn GDFE/ac =
Corn ENSCORE =
Soy GDFE/ac =
Soy ENSCORE =
Six-Year Rotation Energy Cost GDFE/ac

(Best Plan Not Modeled – See text below)

Key Findings

This single case would suggest that:

1. On any individual farm, when soy production practices are identical across all fields in the farming operation, then energy requirements to produce soy are more likely to be near identical from field to field, with any variation attributable to distance from the field to storage.
2. Corn energy requirements might have greater variance from field to field due to slight differences in tillage, planting, chemical/fertilizer application methods, and/or nutrient application rates.

The data provided by the crop consultant for this case study did not model alternative practices, or provide data on the operational parameters that generated the results reported by the software tool. So, this case will be used to illustrate a finding that is evident in several cases.

Producers often farm several land parcels with near-identical practices. For example, this producer's case has seven (7) fields planted in soy during the project year, and each of the seven fields requires between 3.23 GDFE/ac and 3.70 GDFE/ac. This is a pretty tight grouping, and data suggests that the variations are likely due to distance from the field to storage.

The energy required for each of the six corn scenarios has a wider range of 27.46 GDFE/ac to 33.13 GDFE/ac and greater variation evident in the practices that produced corn, but the available data only provides a general indication of what might account for the six different reports on total GDFE/ac required to produce the crops. It is worth noting that at either end of this range, both scenarios, one requiring 27.46 GDFE/ac, and the other requiring 33.13 GDFE/ac, did not report any grain drying, so the variation across these two contrasting fields is likely due to changes in tillage and chemical/fertilizer applications, and nutrient type or application rates.

Tight grouping of energy requirements versus wider range of variation

Crop	GDFE/ac
Soybean	3.23
Soybean	3.23
Soybean	3.23
Soybean	3.70
Soybean	3.63
Soybean	3.63
Soybean	3.30

Crop	GDFE/ac
Corn	33.13
Corn	29.71
Corn	29.81
Corn	27.46
Corn	31.07
Corn	28.24