Final Report for the Iowa Livestock Industry Waste Characterization and Methane Recovery Information Dissemination Project

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Introduction

The Iowa livestock industry generates large quantities of manure and other organic residues; composed of feces, urine, bedding material, waste feed, dilution water, and mortalities. Often viewed as a waste material, little has been done to characterize and determine the usefulness of this resource. The Iowa Department of Natural Resources initiated the process to assess in detail the manure resource and the potential utilization of this resource through anaerobic digestion coupled with energy recovery.

Many of the pieces required to assess the manure resource already exist, albeit in disparate forms and locations. This study began by interpreting and integrating existing Federal, State, ISU studies, and other sources of livestock numbers, housing, and management information. With these data, models were analyzed to determine energy production and economic feasibility of energy recovery using anaerobic digestion facilities on livestock farms. Having these data individual facilities and clusters that appear economically feasible can be identified specifically through the use of a GIS system for further investigation. Also livestock facilities and clusters of facilities with high methane recovery potential can be the focus of targeted educational programs through Cooperative Extension network and other outreach networks, providing a more intensive counterpoint to broadly based educational efforts.

Objective

The purpose of this document is to summarize analytical methods, characterize Iowa livestock wastes, determine fossil fuel displacement by methane use, assess the market potential, and offer recommendations for the implementation of methane recovery technologies.

Methodology

The following outlines the methods for the Iowa Livestock Industry Waste Characterization/Assessment Project. Generally, the methods were designed to collect farm scale census and survey data and to incorporate it into models of methane recovery potential to determine the economic feasibility of methane recovery from Iowa livestock facilities.

- Collect survey and census data on facility size, livestock numbers, and manure management types.
- Classify facilities by general animal type (i.e. swine, dairy, etc), herd size, and housing/confinement manure management categories.
- Connect the housing/confinement type to the most appropriate methane generation scheme (i.e. covered lagoons, complete mix digesters, plug flow digesters, sequencing batch reactors, etc).
- Use methane recovery models, developed by the AgSTAR program of the U.S. EPA (EPA, 1997), to determine the economic feasibility of each facility category for methane recovery.

- Conduct a detailed analysis examining the effects of the price of heating oil and electricity and the resultant benefits for the increased utilization of methane to displace these energy sources.
- Calculate the potential fossil fuel displacement using various economic and resource availability scenarios.
- Conduct a "market assessment" that identifies the roles, strategies, and future steps for stakeholders to encourage the implementation of anaerobic digestion and methane recovery.
- Publish a final report, which details the project methodologies, results, and conclusions.

Waste Characterization

A literature search was conducted to locate and evaluate various data sources related to livestock inventories and the distribution of manure management systems. U.S. Agricultural Statistic data, an ISU Economics Survey, and IDNR permit information were used to create a distribution of facility types (size, waste management, etc). On a state level the size distribution of livestock operations was calculated along with the treatment regimes that were available from EPA sources. For the large operations the IDNR construction permit sets were used to profile the proportions of the manure management systems. State manure management plans were not included in this analysis since they contain very little pertinent information.

The table appendix contains the tables summarized from various Animal and Plant Health Inspection Service (APHIS) and EPA reports that characterize waste management in the U.S., including Iowa, for various animal types. Since the tables were drawn from many different sources, there are some differences on the actual percentages of the individual waste systems. Some of the differences can be attributed to differences in the definition of the waste systems or whether the percentage is expressed on a percent operation or percent animal basis. Appendix A contains the data that utilized U.S. and State Agricultural Census information for determining state and county level total potential energy production from methane and waste generation from each animal species. Calculations of energy potential followed the procedures contained in a WRBEP report (NEOS, 1994). Table 1, in the table appendix, summarizes the potential livestock methane energy in Iowa.

For each county the total number of livestock facilities was divided by type (swine, dairy, etc.). For each livestock type we have developed a distribution of facility sizes and manure systems for the county using a combination of U.S. Ag. Statistics data, the ISU Economics survey (for swine), and IDNR permit data. These charts, which show distribution of livestock numbers, are incorporated with the APHIS information in the tables in the Appendix A. IDNR permit data was used to estimate proportions of manure management systems for the larger facility categories, which were not well represented in the Economics survey and should have been represented in the permit listing if they were built or expanded in the last 15 years. The Iowa Department of Natural Resource permit database was mined to determine common treatment regimes based on animal type.

Tables 2 & 3 show a simplified breakdown of treatment regime based on IDNR and U.S. Environmental Protection categories for livestock waste management systems. Table 4 further details the waste management and herd percentages for the swine category as derived from the ISU Economics survey.

Beef

Iowa beef industry, according to 1997 statistics, was comprised of approximately 1,029,172 cows down from 1,065,744 cows during 1992 (USDA, 1997). These figures do not include heifers and heifer calves. Figure 1 shows the farm and herd profiles for Iowa beef herds. Most of the operations have less than 50 cows while the majority of cows are in operations having 50 or more cows.

Tables 5 through 7 detail the methods used by beef operations to dispose of their manure. This information was obtained from APHIS reports for beef cow-calf and feedlot management. The cow-calf study involved 23 states, including Iowa, which had 85.0 percent of all of the beef cows in the U.S. and 66.3 percent of the beef cow operations. The feedlot study involved 12 western states, including Iowa, which contain 82.1 percent of all cattle on feed in operations of 1,000 head or more. As the APHIS results were not broken out by individual states, we applied the multi-state values to the Iowa herd size distribution. The tables note most of the manure generated in cow-calf operations was applied to land owned or rented by the operation.

Dairy

Iowa dairy industry, according to 1997 statistics, was comprised of approximately 222,142 cows down from 258,925 cows during 1992 (USDA, 1997). These figures only consider milking cows and not dry cows, bulls, heifers, etc. Figure 2 shows the farm and herd profiles for the Iowa dairy herds. Vast majority of farms had 100 or fewer lactating cows in the operation and almost 45% of the cow inventories were in herds of 50 to 99 head.

Dairy management practices, including waste management, for Iowa and 19 other states were profiled in a 1996 three-part APHIS study. These states comprise 83.1 % of the U.S. milk cow inventory and Iowa, when considered alone, has 2.6 % of the U.S. milk cow inventory (APHIS, 1996). As with the beef cattle APHIS data, the management practices are not broken out specifically for Iowa, so the multi-state distribution are presented. Tables 8 and 9 list the housing and milking facility types for operations. For unweaned dairy heifers most of the animals are being housed in individual or multiple animal areas, while the majority of the weaned dairy heifers are housed on pasture, dry lot, or multiple animal areas. Lactating cows in most operations have access to tie stall or stanchion areas, dry lot, or pasture. For milking the vast majority of operations use either a tie stall or stanchion system, but based on the percentage of cows, the majority of operations use a parlor system. This indicates at the larger size farms parlors are more popular than a tie stalls or stanchions.

Tables 10 through 13 from the same APHIS reports provide insight into the types of manure collection, management, and/or storage methods for the dairy industry. Most of the operations less than 200 head used either a gutter or alley scraper while the larger systems tended to use water flushed alley. Manure from scraped systems will have higher solids content compared to a water flushed system. The scraped systems, with higher solids, would be compatible with plug flow digesters, while the water-flushed systems would need either solids separation for plug flow digesters or could use complete mix digesters without solids separation. Solid manure handling systems seem to be fairly common no matter the size of the cowherd (table 11), although slurry and anaerobic lagoon systems became more prominent in the larger cowherds. From table 12 it is clear that most operations with a lagoon only have a single-stage lagoon for holding or treating the dairy waste. Of the systems with lagoon or tank storage, only 29.5 % have any type of solid/liquid separation (table 13).

Dairy manure application details are contained in tables 14 through 17 from the APHIS dairy reports. These tables note the means of disposal (table 14), frequency of application (table 15), method of application (table 16), and specific management practices (table 17). The vast majority of the operations applied the dairy waste directly to land owned or rented by the operation. Frequency of application during the summer months was broadly distributed between daily, weekly, monthly or less, but during the winter months application bimodally distributed with 46% of operations daily and 31% of operations spreading less than once a month. This bimodal distribution presumably reflects the availability of adequate storage and in some of the states, such as California, can apply year around on a daily basis, as indicated in Table 11. In Iowa the less than monthly basis is probably more common than in other states in this study due to the weather conditions experienced here. Most common application method, across all herd sizes, was a broadcast/solid spreader method. Over 100 head, due to the greater prevalence of liquid storage systems, the slurry/surface application also was common. Concerning specific manure management practices, many producers established application rates based on manure nutrient content or crop needs and a majority of operators applied at least 50 feet from a water body.

Swine

Iowa swine industry, according to 1997 statistics, was comprised of approximately 14,651,919 pigs up from 14,153,158 pigs during 1992 (USDA, 1997). Figure 3 below shows the farm and herd profiles for the Iowa swineherds. A majority of the farms have 200 or more hogs, but the majority of hogs are on farms having 1,000 head or more.

Tables 18 through 23 outline the characteristics of the swine industry from two APHIS reports, Part I: Reference of 1995 Swine Management Practices and Part II: Reference of 1995 U.S. Grower/Finisher Health & Management Practices. Tables 18 and 19 typify the production phase and the facility type typically used for each swine production phase. Most operations have farrowing and/or grower/finisher operations but only slightly less than half have nursery facilities. Tables 20 through 23 offer some insight into the types of swine manure storage and handling strategies used by producers. Tables 21, 22, and 23 note the type of flooring, waste storage system, and solid/liquid separation details for grower/finisher operations. For grower/finisher majority of operations are using either deep pit, above or below ground storage, or anaerobic lagoon systems. With grower/finisher systems larger than 10,000 head, anaerobic lagoons without covers tended to dominate.

Poultry

Iowa poultry in 1997 consisted of 24,876,834 layers, 1,017,224 broilers, and 2,552,624 turkeys. The total number of farms was 2,655, down from 3,390 in 1992. Broiler and turkey numbers decreased from 1992 to 1997 but the number of layers nearly doubled. Figure 4 shows the size profile of layer operations in Iowa as taken from the agricultural statistics data (USDA, 1997). Table 24 lists the types of manure handling systems from an APHIS study of layer operations in the central region of the U. S., including Iowa. As one can see from the table most of the layer operations in this region are high-rise, manure belt, or scraper systems. These types of systems would not be very compatible with a methane recovery system. Difficulties include the low moisture content of the manure and the difficulty of capturing the methane due to the housing or manure storage system design.

Economic Feasibility of Methane Recovery

Economic models developed by the US EPA AgSTAR program were used to identify facilities where anaerobic digestion and methane recovery technology might be cost effective. For swine farrow to finish, finishing, dairy tie stall, and dairy free stall operation models were run to calculate methane production, possible generator production, system costs, net present value (NPV), and payback periods for methane recovery facilities under six energy and economic scenarios.

Six scenarios were developed for input to the AgSTAR model representing variations in electricity rates and economic incentives. AgSTAR then calculated the cost and profitability of anaerobic digestion facilities, with results in Table 25 (US EPA 1997). Economic scenarios 1 to 3 had electricity rates of $0.06, $0.08, and $0.12 per kWh, respectively, with no heating cost contribution, a loan rate of 10%, and producer downpayment of 20% of the system cost. Scenario 4 considered electricity rates of $0.06 per kWh with 90% of the $1.00 per gallon liquid propane on-farm heating needs displaced by generator heat recovery. Scenarios 5 and 6 also considered $0.06 per kWh electricity but included different financial assumptions. Both scenarios 5 and 6 had a low loan rate and a lower producer down payment requirement of 5%. Scenario 5 had no heat recovery and scenario 6 had the same heat recovery as scenario 4. Together these scenarios illustrate several of the more important economic and policy alternatives that could affect the future feasibility of anaerobic digestion of manures. Table 25 contains a more detailed description of the energy and economic scenarios, while table 26 details the other common model inputs.

Table 27 (Figures 10, 12, & 13) notes energy production and system capital costs for the farrow to finish systems over the range of size modeled throughout the swine facility analysis. Tables 28 and 29 (Figures 5 & 6) show the economic feasibility, including net present value per sow (NPV) and payback period, for swine farrow to finish operations. Table 30 (Figures 11, 12, & 13) notes energy production and system capital costs for swine finishing systems over the same range of facility sizes. Tables 31 and 32 (Figures 7 & 8) show the economic feasibility, including net present value per sow (NPV) and payback period, for swine finishing operations.

Table 33 (Figures 23 & 28) note energy production and system capital costs for dairy tie stall facilities with plug flow digester systems. Tables 34 and 35 (Figures 14 & 15) show the economic feasibility, including net present value per cow (NPV) and payback period, for dairy tie stall with plug flow digester operations over the range of sizes simulated. Table 36 (Figure 24) notes the energy production and system capital costs for the dairy tie stall with complete mix digester systems. Tables 37 and 38 (Figures 16 & 17) show the economic feasibility, including net present value per cow (NPV) and payback period, for the dairy tie stall with complete mix digester operations.

Table 39 (Figures 25 & 28) notes the energy production and system capital costs for the dairy free stall with plug flow digester systems. Tables 40 and 41 (Figures 18 & 19) below show the economic feasibility, including net present value per cow (NPV) and payback period, for the dairy free stall with plug flow digester operations over the range of sizes simulated. Table 42 (Figure 26) notes the energy production and system capital costs for the dairy free stall with complete mix digester systems. Tables 43 and 44 (Figures 20 & 21) show the economic feasibility, including net present value per cow (NPV) and payback period, for the dairy free stall with complete mix digester operations.

System herd counts that met favorable economic guidelines are listed in table 45. For the farrow-to-finish operations, under all of the scenarios, the herd size had to be greater than 20,000 head for a methane project to be feasible. This is most likely attributed to the diluted manure inputs from the nursery and gestation facilities, which lowers the overall gas production of the system. With an average animal mass of 170 lbs. this translated to facilities with live weights greater than 3,400,000 lbs. From the information provided in the IDNR permit files, there were not currently any farrow-to-finish operations of this magnitude in Iowa. The minimum economically feasible size for finishing operations was approximately 5,000 hogs (scenario #3), at an animal weight of 135 lbs., and total live weight of 675,000 lbs. However, scenario #3 assumed the rate for electricity doubles to $0.12 per kilowatt. Data from IDNR indicates that approximately 179 of the permitted swine operations were this size or larger. The minimum economically feasible size for dairy operations was small enough to accommodate almost all of the permitted sites listed (scenario #3). Even more of the sites would be feasible with scenario #6, which considered the use of no-interest loans to encourage the installation of methane recovery facilities.

An economic scenario similar to scenario 1 but with an electricity rate of $0.08 per kwh was run to find out how much a 30% rate increase would do to decrease herd sizes. For dairy operations more than 5,000 cows and for farrow-to-finish and finishing operations more than 20,000 sows or pigs were still needed to make anaerobic digestion economically feasible. An electricity rate of $0.10 per kwh, a 60% rate increase, was also simulated but not included in table 45. The number of dairy cows to make anaerobic digestion feasible at $0.10 per kwh was between 2,000 to 3,000 cows. For swine farrow-to-finish operations the number of sows was still greater than 20,000 sows and for finishing operations the pigs required was between 10,000 to 15,000 pigs.

Figures 31 & 32 depict the maximum number of farms per county that have an average herd size that matches the herd size needed to be economically feasible in either scenario 3 or 6 (table 45). For scenario 6 Sioux County in northwest Iowa has 18 farms eligible for scenario 3 and 4 farms feasible for scenario 6 based on the agricultural statistics data. For swine operations, central and northwestern Iowa counties had significant number of farms eligible for scenario 6. Only two counties in central Iowa, Hamilton and Hardin counties, had any farms that would be feasible for scenario #3. While large farms appear necessary to achieve economies of scale in methane recovery, another possible solution is the use of centralized anaerobic digestion. Potential energy, MW of electricity output, from swine and dairy manure is graphically presented in Figures 29 & 30, overlaid with the IDNR swine and dairy permitted sites. Centralized digestion facilities could be installed in counties with large livestock facilities that are closely located, or in counties with a high overall manure resource. One example would possibly have a digester installed in Sioux County, in northwest Iowa, where there is a concentration of dairy facilities and a significant amount of manure from swine operations. An analysis of centralized digestion was not conducted since we did not have the proper models to consider the transportation of the waste, and the AgSTAR model simulations were stopped at limiting herd counts.

Fossil Fuel Displacement

One of the important questions for further policy development is the potential of biorenewable resources to displace current fossil fuel use. To address this question, the waste characterization and the economic analysis portions of the study have been combined to assess the energy that could be produced by methane recovery under each of the different scenarios. Table 47 lists a brief description of each policy scenario for fossil fuel displacement while table 48 lists the tons of coal or barrels of oil or cubic feet of natural gas that potentially could be displaced with livestock waste methane recovery. It has been estimated that Iowa consumed 1,140 trillion Btu of energy for year 2000 (IDNR, 2000). This is equivalent to 4.96×10^{7} tons of coal, 1.94×10^{8} barrels of #2 fuel oil, or 1.10×10^{12} million cubic feet of natural gas/LNG. Total energy available from all of Iowa's manure resources would supply approximately 2.81% of Iowa's total present energy use from fossil fuel sources (policy scenario 1). If either scenario 5 or 6 were to become a reality, livestock methane energy recovery would displace 0.15% to 0.23% of Iowa's current total energy use from fossil fuel sources. Methane from livestock facilities has potential to displace a small fraction of the fossil fuel used for Iowa energy requirements.

Market Assessment

Another goal of this project was to identify roles, strategies, and follow-up steps for various stakeholder groups in encouraging implementation of anaerobic digestion and methane recovery technologies. A market assessment focus group meeting was held on June 21st, 2000 at the Madrid 4-H camp to discuss the barriers and opportunities to methane recovery from livestock facilities. Approximately 33 people attended the meeting, representing a wide range of organizations. Organizations represented included educational institutions, regulatory agencies, utilities, technology development and suppliers, policy analysts, nonprofit organizations, and farm operators/organizations. Table 46 notes some of the important issues, barriers, and opportunities that were identified by the meeting participants. A survey was also sent to swine and dairy producers asking them to rank these same issues dealing with methane recovery. The response was extremely poor from the swine producers so only dairy survey respondent information is included in this report. Only 2 out of 27 randomly selected swine operators responded (7% response) versus 8 out of 18 dairy operators responded (44% response).

The questionnaire sent out to the swine and dairy operators asked the producers details about their operations including animal numbers, waste production, waste storage, manure analysis information, energy usage (heat & electricity), manure applied acreage, manure value, issues relating to anaerobic digestion, and had space for additional comments. Even though the survey answers were not always complete, the central theme that the producers noted about anaerobic digestion was the cost of the facilities. Although the survey response was not large enough to generate strong statistical results, it does indicate that dairy producers have some interest in anaerobic digestion and methane recovery, but are aware of the economic barriers. Addressing those economic barriers will be critical for widespread adoption of anaerobic digestion and methane recovery.

Conclusions

The State of Iowa has a widely available manure resource distributed among a range of livestock types and manure management systems. The analyses described in this report show that anaerobic digestion with methane recovery is currently feasible in only limited circumstances on Iowa livestock operations. At the present time dairy and swine operations with scraped or liquid/slurry systems offer the most potential for methane capture. However, present economic conditions are not conducive to the installation of methane recovery facilities at swine or dairy operations. Economic incentives, such as doubling the electricity rate or providing no-interest loans, greatly lower the herd numbers needed to make methane recovery feasible. Other benefits such as odor control or bedding recovery could make anaerobic digestion more attractive to livestock producers, but are difficult to quantify.

Economics also proved to be a central theme for various stakeholders interested in methane recovery. Key issues include the low economic return on systems, the difficulties in obtaining financing for building systems, and the low rate paid for sale of excess electricity. Other important concerns were a lack of technical knowledge or assistance, and the complications interacting with utilities for interconnections.

In light of the issues raised with this study, several conditions must be addressed if Iowa is to realize the potential for energy recovery from methane generated at livestock facilities. First, livestock producers and other stakeholders must be educated about the process of anaerobic digestion and methane recovery on livestock farms and its possible benefits and pitfalls. Dairy producers would be a logical initial focus of these educational efforts due to the response and comments on the survey. Second, the fundamental economics of anaerobic digestion need to improve, as the current energy price and policy structure is not at all encouraging for anaerobic digestion. Since some the possible benefits, such as odor control, are difficult to assign an economic value, other incentives such as low or no-interest loans, tax incentives, or grants may be necessary to encourage installation of systems. Third, utility companies will need to be very involved in any methane recovery program; so utility interconnection and other issues can be streamlined for both the livestock producer and utility company. Fourth, continued research and technology transfer efforts are needed to make anaerobic digestion and methane recovery a simpler, less management intensive, and more efficient process for the livestock producer or turnkey operator. Finally, centralized digestion with expert management should be explored as an option in areas with concentrated manure resources. A centralized system serving a number of satellite farms could encourage and demonstrate anaerobic digestion and methane recovery benefits, capturing the economies of scale of this technology for smaller and mid-sized livestock producers. While there is no single solution to the challenge of increasing methane recovery from livestock manure, a coordinated effort to implement these strategies would help Iowa realize the energy potential from this biorenewable resource.

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Appendix A

Table 1: Summary of Potential Livestock Methane Energy in Iowa (based on county animal census data)

Animal	Animal Numbers (#)	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Volatile Solids (tons/yr)	Potential Energy (MMBtu/yr)
Feedlot Cattle	3,306,618	11,077	3,439,709	2,579,782	14,859,544
Dairy Cows	222,142	1,555	454,058	408,652	2,402,876
Swine	14,651,919	10,989	3,208,770	2,567,016	13,348,484
Poultry Layers	24,876,834	808	217,921	196,129	1,214,431
Poultry Boilers	1,017,224	22	5,941	5,347	33,106
Turkeys	2,552,624	217	60,561	36,337	224,996
Totals		24,668	7,386,961	5,793,263	32,083,438

Table 2: Iowa Department of Natural Resources Permitted Facility Waste Management Profile

Animal	Waste Handling Method (# of Facilities)			
	Runoff Control	Basin	Tank	Lagoon
Beef	16	1		
Dairy		17	1	1
Swine		371	120	175
Poultry			15	

Notes: Two facilities were combined beef & hog (1 runoff control & 1 basin).
Two veal facilities (1 basin & 1 lagoon)

Table 3: EPA Waste Handling and Management for Livestock Types in Iowa

Animal	Anaerobic Lagoon %[1]	Dry Lot %	Liquid/ Slurry %	Pasture %	Daily Spread %	Solid Storage %	Pit Storage %	Litter %	Other %
Beef		13		87					
Dairy	3		20		8	65			4
Swine[2]	3	30					50		13
Layers	2		4			90			4
Boilers								100	
Turkeys								100	

Source: EPA. Feedlot Industry Sector Profile Revised Draft Report. 1998
[1]all percentages expressed here are based on operation totals.
[2]the total swine operations only add up to 96%, this is an error in the source material

Table 4: Swine Herd Percentages and Waste Management Strategies

Herd Category	Overall % of Hog #'s	Waste Management System (% of Pigs within Herd Category)				
		Solid Manure	Deep Pit	Earthen Basin	Formed Storage	Lagoon
0-250	2.79	86.7	8.6	1.1	3.3	0
251-500	10.17	69.9	23.1	1.2	5.6	0
501-1000	17.14	56.3	29.3	2.4	5.4	6.6
1001-2000	69.9*	N/A	21.4	1.7	4.3	2.2
2001-4000		N/A	16.6	1.7	5.2	4.4
4001 or more		N/A	21.1	3.0	9.1	9.0

*Covers 1001-2000, 2001-4000, and 4001 or more categories
Source: Iowa State University Hog Operation and Management Survey, 2000

Table 5: Feedlot Manure Disposal Based on Percentage of Operations and Cows

Manure Disposal Method	% of Operations	% of Beef Cows
Drag or harrow pastures	43.0	44.2
Hauled and spread onto land used for grazing or forage production for operation	25.5	34.1
Hauled and spread onto other land	21.9	25.4
Other	2.5	1.7
No disposal	34.7	32.4

Source: APHIS. 1998. *National Animal Health Monitoring System. Part III: Reference of 1997 Beef Cow-Calf Production Management and Disease Control.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 6: Cow-Calf Operations Manure Disposal Methods by % of Operations

	% of Operations		
Manure Disposal Method	1,000 – 7,999	8,000 or more	All Operations
Applied on land owned or managed by the feedlot	90.9	61.7	82.9
Sold	5.0	26.7	11.0
Given away	15.1	57.3	26.7
Removed by paying someone to take it	0.8	9.9	3.3
Removed by another method	2.7	5.2	3.4

Source: APHIS. 1999. *National Animal Health Monitoring System. Part I: Baseline Reference of Feedlot Management Practices, 1999.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 7: Cow-Calf Operations Manure Disposal Methods by % of Manure

	% of Manure		
Manure Disposal Method	1,000 – 7,999	8,000 or more	All Operations
Applied on land owned or managed by the feedlot	74.6	25.5	33.4
Sold	4.8	14.8	13.2
Given away	16.2	48.5	43.3
Removed by paying someone to take it	1.9	8.4	7.3
Removed by another method	2.5	2.8	2.8

Source: APHIS. 1999. *National Animal Health Monitoring System. Part I: Baseline Reference of Feedlot Management Practices, 1999.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 8: Dairy Housing Systems Based on Animal Types

	% of Operations			
Housing Type	Unweaned Dairy Heifers	Weaned Dairy Heifers	Lactating Dairy Cows	Maternity
Freestall	2.5	9.7	24.4	5.6
Individual animal area	29.7	6.6	2.3	38.3
Multiple animal area	40.0	73.9	17.9	26.3
Tie stall or stanchion	10.5	11.5	61.4	26.3
Drylot	9.1	38.1	47.2	28.9
Pasture	7.4	51.4	59.6	41.9
Hutch	32.5	N/A	N/A	N/A

Source: APHIS. 1996. *National Animal Health Monitoring System. Part I: Reference of 1996 Dairy Management Practices.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 9: Dairy Milking Facility Type Based on % of Operations and Cows

Milking Facility Type	% of Operations	% of Cows
Parlor	28.8	54.9
Tie stall or stanchion	69.5	43.9
Other	2.9	4.3

Source: APHIS. 1996. *National Animal Health Monitoring System. Part I: Reference of 1996 Dairy Management Practices.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 10: Type of Dairy Manure Collection System

	% of Operations			
	Number of Dairy Cows			
Method	Less than 100	100 - 199	200 or more	Total
Gutter scraper	74.0	34.7	9.0	63.2
Alley scraper (Mechanical or Tractor)	50.2	82.4	85.0	57.7
Water flushed alley	0.2	4.3	26.6	2.8
Other	1.3	0.5	0.1	1.1

Source: APHIS. 1996. *National Animal Health Monitoring System. Part III: Reference of 1996 Dairy Health and Health Management.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 11: Type of Dairy Manure Management or Storage System

	% of Operations			
	Number of Dairy Cows			
Waste System	Less than 100	100 - 199	200 or more	Total
Below floor slurry or deep pit	4.7	19.6	16.9	7.9
Slurry storage in tanks	3.2	10.9	17.5	5.4
Slurry storage in earth basin	13.5	25.2	27.8	16.3
Anaerobic lagoon w/cover	0.2	0.3	1.1	0.3
Anaerobic lagoon w/o cover	5.7	18.2	46.7	10.7
Aerated Lagoon	0.5	3.3	8.3	1.5
Manure Pack (Inside barn)	22.3	20.4	14.1	21.4
Outside storage for solids (not in drylot or pen)	37.9	33.0	30.1	36.6
Outside storage in drylot or pens	14.8	11.5	22.0	14.9
Solids in building w/o cattle access	2.8	4.1	2.4	3.0
Other	2.1	1.8	1.6	2.0

Source: APHIS. 1996. *National Animal Health Monitoring System. Part III: Reference of 1996 Dairy Health and Health Management.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 12: % of Dairy Lagoon Systems with Single or Multiple Stages

Stages	% of Operations
Single stage	84.0
Multiple stage	16.6

Source: APHIS. 1996. *National Animal Health Monitoring System. Part III: Reference of 1996 Dairy Health and Health Management.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 13: % of Dairy Lagoons or Tank Storages with Solid Separation

Response	% of Operations
Yes	2.3
No	29.5
No tank or lagoon storage	68.2

Source: APHIS. 1996. *National Animal Health Monitoring System. Part III: Reference of 1996 Dairy Health and Health Management.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 14: Dairy Manure Disposal Method

	% of Operations			
	Number of Dairy Cows			
Method	Less than 100	100 - 199	200 or more	Total
Applied on land owned or rented by the operation	99.4	98.6	94.7	98.9
Sold or received other compensation	0.8	2.7	17.5	2.3
Gave away	4.9	8.7	22.6	6.8
Composted	3.3	6.2	16.3	4.7

Source: APHIS. 1996. *National Animal Health Monitoring System. Part III: Reference of 1996 Dairy Health and Health Management.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 15: Frequency of Dairy Manure Application

Frequency	% of Operations	
	Summer	Winter
Daily	30.4	46.5
Weekly	25.5	14.7
Monthly	10.8	7.8
Less than monthly	33.3	31.0

Source: APHIS. 1996. *National Animal Health Monitoring System. Part III: Reference of 1996 Dairy Health and Health Management.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 16: Dairy Manure Application Method

Application Method	% of Operations Number of Dairy Cows Less than 100	100 - 199	200 or more	Total
Irrigation	3.1	11.2	40.5	7.0
Broadcast/solid spreader	90.6	85.1	75.8	88.7
Slurry (surface application)	17.7	38.5	44.6	22.7
Slurry (subsurface injection)	3.6	5.9	8.6	4.3
Other methods	0.0	0.4	1.0	0.1

Source: APHIS. 1996. *National Animal Health Monitoring System. Part III: Reference of 1996 Dairy Health and Health Management.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 17: Dairy Manure Specific Management Practices

Management Practice	% of Operations Number of Dairy Cows Less than 100	100 - 199	200 or more	Total
Analyzed nutrient content of the manure	10.3	26.4	28.6	14.0
Established manure application rate based on manure nutrient or crop need	41.7	50.5	43.3	43.2
Applied manure a minimum of 50 ft from a water body	77.9	77.2	82.5	78.1
Incorporated manure into soil within 24 hours after application	15.8	22.8	31.5	17.9

Source: APHIS. 1996. *National Animal Health Monitoring System. Part III: Reference of 1996 Dairy Health and Health Management.* U. S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 18: Production Phases Within Swine Operations

Production Phase	% of Operations
Farrowing	70.7
Nursery	46.5
Grower/Finisher	85.6

Source: APHIS. 1995. *National Animal Health Monitoring System. Part I: Reference of 1995 Swine Management Practices.* U.S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 19: Facility Types in Each Production Phase by % of Operations and Hogs

Facility Type	% of Operations Farrow	Nursery	Grower/ Finisher	% of Pigs Farrow	Nursery	Grower/ Finisher
Total confinement	46.4	59.5	26.0	81.3	87.2	56.5
Open building with no outside access	9.8	9.9	11.9	5.9	5.8	11.3
Open building with outside access	30.5	26.1	45.5	9.7	5.6	27.8
Lot with hut or no building	5.7	3.0	9.9	1.6	1.1	2.9
Pasture with hut or no building	7.6	1.5	6.7	1.5	0.3	1.5

Source: APHIS. 1995. *National Animal Health Monitoring System. Part I: Reference of 1995 Swine Management Practices.* U.S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 20: Type of Grower/Finisher Facility Waste Handling System

System	% of Operations in Growth Category		
	Farrowing	Nursery	Grower/Finisher
None	13.8	4.3	14.8
Pit-holding	25.5	33.7	23.2
Mechanical scraper/tractor	12.0	17.6	24.9
Hand cleaned	38.2	29.9	27.2
Flushed-under slats	5.3	9.4	2.4
Flushed-open gutter	3.0	2.1	3.4
Other	2.2	3.0	4.1

Source: APHIS. 1995 *National Animal Health Monitoring System, Part II: Reference of 1995 U.S. Grower/Finisher Health & Management Practices.* U.S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 21: Grower/Finisher Operation Flooring Types

Flooring Types	% of Operations	% of Hogs
Concrete slats only	26.3	38.8
Metal slats only	3.6	0.8
Fiberglass or plastic slats only	2.7	0.8
Slats and other flooring combined (partial slats)	33.0	23.9
Solid concrete only	61.6	31.4
Dirt/pasture only	12.1	3.2
Wood only	0.0	0.0
Other	1.9	1.1

Source: APHIS. 1995 *National Animal Health Monitoring System, Part II: Reference of 1995 U.S. Grower/Finisher Health & Management Practices.* U.S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 22: Grower/Finisher Waste Storage Systems

System	All Operations (%)	Less than 2,000 head	2,000-9,999 head	10,000 or more head
Below floor slurry or deep pit	49.9	43.6	70.4	47.9
Above ground slurry storage	5.6	4.1	10.3	8.3
Below ground slurry storage	19.4	17.3	25.6	26.8
Anaerobic lagoon with cover	1.8	2.2	0.5	2.0
Anaerobic lagoon without cover	20.9	17.4	29.2	81.8
Aerated lagoon	2.6	1.3	6.9	1.0
Oxidation ditch	2.2	2.9	0.1	0.0
Solids separated from liquids	4.6	4.1	5.9	4.7
Other	0.4	0.6	0.0	1.1

Source: APHIS. 1995 *National Animal Health Monitoring System, Part II: Reference of 1995 U.S. Grower/Finisher Health & Management Practices.* U.S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 23: Grower/Finisher Operations Disposing of Liquid/Solid Waste or Unseparated Waste

Waste Type	% of Operations
Separated liquids and solids	4.3
Unseparated liquids and solids	96.2

Source: APHIS. 1995 *National Animal Health Monitoring System, Part II: Reference of 1995 U.S. Grower/Finisher Health & Management Practices.* U.S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 24: Manure Handling Methods for Layer Operations in the Central U. S.

Primary Manure Handling Method	% of Farm Sites in the Central U. S.
High Rise (pit at ground level with house above)	48.1
Deep Pit (below ground)	6.4
Shallow Pit (pit at ground level with raised cages)	1.6
Flush System to a Lagoon	0.0
Manure Belt	20.2
Scraper System (not flush)	23.7

Source: APHIS. 1999 *National Animal Health Monitoring System, Part II: Reference of 1999 U.S. Table Egg Layer Management in the U. S.* U.S. Department of Agriculture, Animal and Plant Health Inspection Service.

Table 25: AgSTAR Model Scenario Descriptions

Scenario (#)	Electricity Rate ($/kwh)	Liquid Propane (% heat supp.) & ($/gallon)	Loan Rate %	Producer Downpayment %
1	0.06	0	10	20
2	0.08	0	10	20
3	0.12	0	10	20
4	0.06	90 & 1.00	10	20
5	0.06	0	0	5
6	0.06	90 & 1.00	0	5

Table 26: Other AgSTAR Model Input Values

Model Parameter	Input or Assumed Value
Climate\Location	Story County, IA
Livestock Systems	Swine Farrow to Finish & Finishing Dairy Free & Tie Stall
Waste Collection Method	Swine - Plug Pull or Cascade Dam Dairy – Flush Parlor and Scrape Rest
Storage System	Storage Tank
Digester Type	Swine - Complete Mix Dairy – Complete Mix or Plug Flow
Other Benefits	None
Any Other Model Values	AgSTAR Default Values

Table 27: Swine Farrow to Finish System Energy Production and Costs

Herd[a] (#)	Total Manure[b] (gal/d)	Gas Production (cu ft/d)	Max. Energy (kwh)	Mix Tank ($)	Complete Mix Digester ($)	Generator Building ($)	Total Cost ($)
50	503	1,298	33,580	17,260	33,007	19,025	94,292
100	1,011	2,608	67,890	19,133	47,578	23,138	114,848
200	1,980	5,111	133,225	21,863	72,402	30,969	150,233
400	4,021	10,378	270,465	26,293	119,781	47,419	218,493
600	6,067	15,654	408,070	29,997	164,611	63,912	283,520
800	8,138	20,998	547,135	33,368	208,685	80,581	347,634
1,000	10,203	26,322	686,200	36,481	251,707	97,250	410,437
1,500	15,209	39,241	1,022,730	43,408	353,957	137,588	559,953
2,000	20,405	52,645	1,372,400	49,974	457,563	179,500	712,037
3,000	30,566	78,860	2,055,680	61,825	656,982	261,400	1,005,207
5,000	51,109	131,854	3,093,812	83,544	1,051,702	427,038	1,587,284
10,000	102,272	263,845	6,878,790	132,085	2,015,225	839,512	3,011,822
15,000	153,472	395,931	9,125,000	177,066	2,966,579	1,110,750	4,277,396
20,000	204,635	527,921	9,125,000	220,152	3,910,481	1,108,750	5,264,383

[a] only sow numbers, used default AGSTAR values for Nursery, Grower, Finisher, and Boar numbers.
[b] includes sow, nursery, grower, finisher, and boar manure production

Table 28: Swine Farrow to Finish System Methane Recovery Economics

Herd	Scenario #1		Scenario #2		Scenario #3	
(#)	NPV ($/sow)	Payback (years)	NPV ($/sow)	Payback (years)	NPV ($/sow)	Payback (years)
50	-1,436.96	69.3	-1359.00	48.0	-1203.10	29.7
100	-820.74	43.8	-744.71	30.2	-592.66	18.7
200	-521.34	36.6	-457.87	24.7	-330.95	15.0
400	-380.90	35.2	-327.94	23.0	-222.02	13.6
600	-329.69	34.2	-280.27	22.0	-181.41	12.8
800	-303.34	33.6	-255.68	21.4	-160.35	12.4
1,000	-286.42	33.1	-239.82	20.9	-146.61	12.0
1,500	-258.78	31.6	-213.59	19.8	-123.20	11.4
2,000	-246.81	31.1	-202.32	19.4	113.35	11.1
3,000	-231.12	30.1	-187.34	18.7	-99.78	10.6
5,000	-218.20	29.3	-174.98	18.1	-88.55	10.3
10,000	-205.76	28.4	-162.97	17.5	-77.39	9.9
15,000	-183.43	24.5	-140.78	15.6	-55.49	9.1
20,000	-147.52	19.3	-104.95	13.0	-19.82	7.9

Table 29: Swine Farrow to Finish System Methane Recovery Economics

Herd	Scenario #4		Scenario #5		Scenario #6	
(#)	NPV ($/sow)	Payback (years)	NPV ($/sow)	Payback (years)	NPV ($/sow)	Payback (years)
50	-1407.62	59.4	-698.32	69.3	-668.98	59.4
100	-791.40	37.3	-370.91	43.8	-341.57	37.3
200	-491.99	29.9	-227.27	36.6	-197.78	29.9
400	-351.56	27.2	-166.95	35.2	-137.61	27.2
600	-300.35	25.7	-144.61	34.2	-115.27	25.7
800	-274.00	24.8	-133.14	33.6	-103.80	24.8
1,000	-257.08	24.2	-125.66	33.1	-96.32	24.2
1,500	-229.44	22.8	-112.57	31.6	-83.23	22.8
2,000	-217.47	22.3	-107.36	31.1	-78.02	22.3
3,000	-201.77	21.4	-99.88	30.1	-70.54	21.4
5,000	-188.86	20.7	-93.86	29.3	-64.52	20.7
10,000	-176.42	19.9	-87.80	28.4	-58.46	19.9
15,000	-154.09	17.6	-71.74	24.5	-42.40	17.6
20,000	-118.18	14.5	-44.42	19.3	-15.08	14.5

Table 30: Finishing System Energy Production and Costs

Herd (#)	Total Manure (gal/d)	Gas Production (cu ft/d)	Max. Energy (kwh)	Mix Tank ($)	Complete Mix Digester ($)	Generator Building ($)	Total Cost ($)
50	69	175	4,380	14,591	16,623	15,525	71,739
100	137	350	8,760	15,174	19,694	16,050	75,917
200	275	700	17,885	16,022	24,692	17,144	82,858
400	550	1,400	36,135	17,270	33,074	19,331	94,675
600	825	2,100	54,385	18,265	40,549	21,519	105,333
800	1,100	2,799	72,635	19,130	47,553	23,706	115,390
1,000	1,375	3,499	90,885	19,911	54,258	25,894	125,063
1,500	2,062	5,249	136,510	21,636	70,195	31,362	148,193
2,000	2,750	6,998	182,135	23,153	85,389	36,831	170,373
3,000	4,125	10,498	273,385	25,831	144,900	47,769	213,090
5,000	6,875	17,496	455,885	30,415	169,921	69,644	294,980
10,000	13,749	34,992	912,135	39,922	301,472	124,331	490,725
15,000	20,624	52,488	1,368,385	48,167	428,485	179,019	680,671
20,000	27,499	69,984	1,824,270	55,759	553,150	233,662	867,571

Table 31: Finishing System Methane Recovery Economics

Herd	Scenario #1		Scenario #2		Scenario #3	
(#)	NPV ($/pig)	Payback (years)	NPV ($/pig)	Payback (years)	NPV ($/pig)	Payback (years)
50	-1191.62	404.4	-1181.44	280	-1161.12	173.3
100	-620.93	214.0	-610.76	148.1	-590.42	91.7
200	-329.18	114.4	-318.80	79.2	-298.04	49
400	-178.95	64.7	-168.46	44.8	-147.49	27.7
600	-127.24	47.8	-116.71	33.1	-95.67	20.5
800	-100.75	39.2	-90.21	27.2	-69.13	16.8
1,000	-84.53	34	-73.98	23.5	-52.88	14.6
1,500	-62.37	26.9	-51.83	18.6	-30.75	11.5
2,000	-51.06	23.3	-40.57	16.2	-19.60	10
3,000	-39.46	19.8	-29.09	13.7	-8.35	8.4
5,000	-29.71	16.7	-19.49	11.5	0.97	7.1
10,000	-21.74	14.2	-11.64	9.8	8.55	6
15,000	-18.78	13.2	-8.74	9.1	11.34	5.6
20,000	-17.18	12.7	-7.17	8.7	8.21	5.4

Table 32: Finishing System Methane Recovery Economics

Herd	Scenario #4		Scenario #5		Scenario #6	
(#)	NPV ($/pig)	Payback (years)	NPV ($/pig)	Payback (years)	NPV ($/pig)	Payback (years)
50	-1172.20	218.8	-629.66	404.4	-610.24	218.8
100	-601.52	115.8	-323.58	214	-304.17	115.8
200	-309.77	62.5	-195.66	114.4	-147.51	62.5
400	-159.54	35.5	-102.67	64.7	-66.83	35.5
600	-107.83	26.3	-70.66	47.8	-39.07	26.6
800	-81.34	21.6	-54.26	39.2	-24.84	21.6
1,000	-68.34	20.2	-44.22	34.0	-16.13	18.7
1,500	-42.96	14.8	-30.53	26.9	-4.27	14.8
2,000	-31.65	12.8	-17.69	23.3	1.72	12.8
3,000	-20.05	10.8	-11.64	19.8	7.77	10.8
5,000	-10.31	9.0	-6.61	16.7	12.80	9.0
10,000	-2.33	7.6	-2.52	14.2	16.89	7.6
15,000	0.62	7.0	-1.01	13.2	18.40	7.0
20,000	0.11	6.7	-0.19	12.7	19.22	6.7

Table 33: Dairy Tie Stall with Plug Flow Digester Energy Production and Costs

Herd (#)	Total Manure (gal/d)	Gas Production (cu ft/d)	Max. Energy (kwh)	Mix Tank ($)	Plug Flow Digester ($)	Generator Building ($)	Total Cost ($)
50	899	2,748	71,,540	15,262	26,140	23,575	89,977
100	1,798	5,496	143,080	16,152	35,207	32,150	108,509
200	3,596	10,991	286,525	17,462	50,542	49,344	142,348
400	7,193	21,982	573,050	19,419	77,253	83,688	205,359
600	10,766	32,911	857,750	20,994	101,590	117,812	265,397
800	14,374	43,933	1,145,370	22,391	125,004	152,288	324,683
1,000	17,982	54,955	1,432,625	23,664	147,677	186,719	383,060
1,500	26,972	82,379	2,147,660	26,497	202,157	272,600	526,078
2,000	35,963	109,910	2,863,425	29,024	254,816	358,219	667,060
3,000	53,945	164,865	4,298,240	33,552	356,984	530,200	945,735
5,000	89,908	274,597	7,159,110	41,469	554,525	873,112	1,494,107

Table 34: Dairy Tie Stall with Plug Flow Digester Methane Recovery Economics

Herd	Scenario #1		Scenario #2		Scenario #3	
(#)	NPV ($/lac. cow)	Payback (years)	NPV ($/lac. cow)	Payback (years)	NPV ($/lac. cow)	Payback (years)
50	-1187.68	31.1	-1021.60	21.5	-689.46	13.3
100	-611.29	20.2	-454.25	13.9	-140.17	8.6
200	-385.95	17.9	-258.85	12	-4.65	7.2
400	-281.96	17.2	-176.04	11.1	35.79	6.5
600	-242.76	16.6	-143.90	10.5	53.81	6.1
800	-222.79	16.2	-127.46	10.2	63.19	5.9
1,000	-209.99	15.9	-116.78	10	69.63	5.7
1,500	-191.05	15.4	-100.66	9.5	80.10	5.4
2,000	-180.76	15.1	-91.79	9.3	86.15	5.3
3,000	-169.67	14.7	-82.11	9	93.01	5.1
5,000	-159.08	14.3	-72.65	8.7	100.21	4.9

Table 35: Dairy Tie Stall with Plug Flow Digester Methane Recovery Economics

Herd	Scenario #4		Scenario #5		Scenario #6	
(#)	NPV ($/lac. cow)	Payback (years)	NPV ($/lac. cow)	Payback (years)	NPV ($/lac. cow)	Payback (years)
50	-1129.00	26.8	-482.86	31.1	-424.16	26.8
100	-559.06	17.6	-186.29	20.2	-127.61	17.3
200	-327.27	14.6	-106.87	17.9	-48.19	14.5
400	-223.28	13.2	-80.72	17.1	-22.04	13.1
600	-184.08	12.5	-69.41	16.6	-10.72	12.4
800	-164.10	11.9	-63.67	16.2	-4.99	11.9
1,000	-151.07	11.6	-59.77	15.9	-1.10	11.6
1,500	-132.37	11	-55.37	15.6	5.00	11
2,000	-122.08	10.7	-51.83	15.3	8.56	10.7
3,000	-110.99	10.3	-47.72	14.9	12.65	10.3
5,000	-100.40	10	-43.70	14.5	16.64	10

Table 36: Dairy Tie Stall with Complete Mix Digester Energy Production and Costs

Herd (#)	Total Manure (gal/d)	Gas Production (cu ft/d)	Max. Energy (kwh)	Mix Tank ($)	Plug Flow Digester ($)	Generator Building ($)	Total Cost ($)
50	899	2,748	71,540	15,262	20,188	23,575	84,025
100	1,798	5,496	143,080	16,152	25,509	32,150	98,811
200	3,596	10,991	286,525	17,462	34,465	49,344	126,270
400	7,193	21,982	573,050	19,419	49,992	83,688	178,098
600	10,766	32,911	857,750	20,994	64,093	117,812	227,899
800	14,374	43,933	1,145,370	22,391	77,632	152,288	277,310
1,000	17,982	54,955	1,432,625	23,664	90,724	186,719	326,107
1,500	26,972	82,379	2,147,660	26,497	122,133	272,600	446,230
2,000	35,963	109,910	2,863,425	29,024	152,446	358,438	564,907
3,000	53,945	164,865	4,298,240	33,552	211,172	530,200	799,924
5,000	89,908	274,775	7,163,490	41,469	324,532	873,638	1,264,639

Table 37: Dairy Tie Stall with Complete Mix Digester Methane Recovery Economics

Herd	Scenario #1		Scenario #2		Scenario #3	
(#)	NPV ($/lac. cow)	Payback (years)	NPV ($/lac. cow)	Payback (years)	NPV ($/lac. cow)	Payback (years)
50	-1,087.12	29.0	-921.04	20.1	-588.88	12.4
100	-529.37	18.4	-372.33	12.7	-58.25	7.8
200	-318.05	15.9	-190.95	10.6	63.26	6.4
400	-224.39	14.9	-118.47	9.6	93.36	5.6
600	-189.97	14.2	-91.11	9.0	106.60	5.2
800	-172.77	13.9	-77.44	8.7	113.21	5.0
1,000	-161.88	13.6	-68.68	8.5	117.74	4.8
1,500	-146.19	13.3	-55.81	8.1	124.95	4.6
2,000	-137.72	12.8	-48.75	7.9	129.19	4.5
3,000	-128.61	12.5	-41.05	7.6	134.06	4.3
5,000	-120.41	12.1	-33.98	7.4	138.87	4.1

Table 38: Dairy Tie Stall with Complete Mix Digester Methane Recovery Economics

Herd	Scenario #4		Scenario #5		Scenario #6	
	NPV	Payback	NPV	Payback	NPV	Payback
(#)	($/lac. cow)	(years)	($/lac. cow)	(years)	($/lac. cow)	(years)
50	-1,028.44	25.1	-428.92	29.0	-370.24	25.1
100	-470.69	15.7	-142.35	18.4	-83.67	15.7
200	-259.37	12.9	-70.76	15.9	-11.77	12.9
400	-165.71	11.4	-50.00	14.9	8.84	11.4
600	-131.28	10.6	-41.20	14.2	17.59	10.6
800	-114.08	10.2	-37.00	13.9	21.84	10.2
1,000	-103.20	9.8	-34.16	13.6	24.71	9.8
1,500	-87.51	9.4	-29.68	13.1	29.17	9.3
2,000	-79.04	9.1	-27.09	12.8	31.75	9.1
3,000	-69.93	8.7	-24.18	12.5	34.67	8.7
5,000	-61.73	8.4	-21.35	12.1	37.48	8.4

Table 39: Dairy Free Stall with Plug Flow Digester Energy Production and Costs

Herd	Total Manure	Gas Production	Max. Energy	Mix Tank	Plug Flow Digester	Generator Building	Total Cost
(#)	(gal/d)	(cu ft/d)	(kwh)	($)	($)	($)	($)
50	905	2,763	71,905	15,269	26,203	23,619	90,091
100	1,809	5,527	143,810	16,161	35,312	32,238	108,711
200	3,619	11,053	287,985	17,476	50,722	49,519	142,717
400	7,238	22,106	576,335	19,441	77,571	84,081	206,093
600	10,823	33,066	861,765	21,017	101,965	118,294	266,276
800	14,459	44,166	1,151,210	22,422	125,545	152,988	325,955
1,000	18,095	55,266	1,440,655	23,702	148,378	187,681	384,762
1,500	27,142	82,899	2,161,165	26,547	203,164	274,044	528,755
2,000	36,189	110,532	2,881,675	29,085	256,124	360,406	670,616
3,000	54,284	165,798	4,322,330	33,632	358,882	533,088	950,602
5,000	90,473	276,331	7,204,005	41,586	557,585	878,494	1,502664

Table 40: Dairy Free Stall with Plug Flow Digester Methane Recovery Economics

Herd	Scenario #1		Scenario #2		Scenario #3	
	NPV	Payback	NPV	Payback	NPV	Payback
(#)	($/lac. cow)	(years)	($/lac. cow)	(years)	($/lac. cow)	(years)
50	-1,187.90	30.9	-1,020.98	21.4	-687.14	13.3
100	-612.47	20.2	-454.97	13.9	-139.97	8.6
200	-388.36	18	-261.26	12	-7.06	7.2
400	-284.46	17.3	-178.54	11.1	33.29	6.5
600	-244.77	16.7	-145.91	10.6	51.80	6.1
800	-224.97	16.3	-129.65	10.3	61.00	5.9
1,000	-212.36	16.1	-119.15	10	67.26	5.7
1,500	-193.60	15.6	-103.22	9.6	77.55	5.5
2,000	-183.32	15.3	-94.35	9.4	83.60	5.3
3,000	-171.97	14.9	-84.41	9.1	90.71	5.1
5,000	-161.56	14.5	-75.14	8.8	97.72	4.9

Table 41: Dairy Free Stall with Plug Flow Digester Methane Recovery Economics

Herd	Scenario #4		Scenario #5		Scenario #6	
	NPV	Payback	NPV	Payback	NPV	Payback
(#)	($/lac. cow)	(years)	($/lac. cow)	(years)	($/lac. cow)	(years)
50	-1,129.22	26.8	-482.18	30.9	-423.50	26.8
100	-553.79	17.3	-186.68	20.2	-127.99	17.3
200	-329.68	14.6	-108.86	18	-50.18	14.6
400	-225.78	13.2	-82.50	17.3	-23.82	13.2
600	-186.09	12.4	-70.84	16.7	-12.16	12.4
800	-166.29	12	-65.23	16.3	-6.55	12
1,000	-153.68	11.7	-61.53	16.1	-2.85	11.6
1,500	-134.92	11.1	-55.37	15.6	3.32	11.1
2,000	-124.64	10.8	-51.83	15.3	6.85	10.8
3,000	-113.29	10.4	-47.72	14.9	10.97	10.4
5,000	-102.88	10.1	-43.70	14.5	14.98	10.1

Table 42: Dairy Free Stall Complete Mix Digester Energy Production and Costs

Herd (#)	Total Manure (gal/d)	Gas Production (cu ft/d)	Max. Energy (kwh)	Mix Tank ($)	Plug Flow Digester ($)	Generator Building ($)	Total Cost ($)
50	905	2,763	71,905	15,269	20,225	23,619	84,112
100	1,809	5,527	143,810	16,161	25,570	32,238	98,969
200	3,619	11,053	287,985	17,476	34,570	49,519	126,565
400	7,238	22,106	576,335	19,441	50,176	84,081	178,698
600	10,823	33,066	861,765	21,017	64,309	118,294	228,620
800	14,459	44,166	1,151,210	22,422	77,944	152,988	278,354
1,000	18,095	55,266	1,440,655	23,702	91,129	187,681	327,512
1,500	27,142	82,899	2,161,165	26,547	122,713	274,044	448,304
2,000	36,189	110,532	2,881,675	29,085	153,198	360,406	567,689
3,000	54,284	165,798	4,322,330	33,632	212,262	533,088	803,982
5,000	90,473	276,331	7,204,005	41,586	326,286	878,494	1,271,366

Table 43: Dairy Free Stall Complete Mix Digester Methane Recovery Economics

Herd	Scenario #1		Scenario #2		Scenario #3	
(#)	NPV ($/lac. cow)	Payback (years)	NPV ($/lac. cow)	Payback (years)	NPV ($/lac. cow)	Payback (years)
50	-1,086.90	28.9	-919.98	20	-586.12	12.4
100	-530.18	18.4	-372.68	12.6	-57.56	7.8
200	-320.14	15.9	-193.04	10.7	61.17	6.4
400	-226.61	15	-120.69	9.7	91.14	5.6
600	-191.76	14.3	-92.90	9.1	104.81	5.2
800	-174.71	14.0	-79.39	8.8	111.27	5.0
1,000	-164.00	13.7	-70.79	8.5	115.62	4.9
1,500	-148.29	13.2	-57.91	8.2	122.86	4.6
2,000	-139.85	12.9	-50.88	7.9	127.26	4.5
3,000	-130.69	12.6	-43.13	7.7	131.99	4.3
5,000	-122.49	12.2	-36.06	7.4	136.80	4.2

Table 44: Dairy Free Stall Complete Mix Digester Methane Recovery Economics

Herd	Scenario #4		Scenario #5		Scenario #6	
(#)	NPV ($/lac. cow)	Payback (years)	NPV ($/lac.cow)	Payback (years)	NPV ($/lac. cow)	Payback (years)
50	-1,028.22	25	-428.02	28.9	-369.34	25
100	-471.50	15.7	-142.54	18.4	-83.86	15.7
200	-261.46	13	-72.28	15.9	-13.59	13
400	-167.93	11.5	-51.48	15	7.21	11.5
600	-133.08	10.7	-42.41	14.3	16.27	10.7
800	-116.03	10.2	-38.28	14	20.41	10.2
1,000	-105.32	9.9	-35.60	13.7	23.08	9.9
1,500	-89.61	9.4	-31.07	13.2	27.61	9.4
2,000	-80.97	9.1	-28.52	12.9	30.17	9.1
3,000	-72.00	8.8	-25.57	12.6	33.11	8.8
5,000	-63.62	8.5	-22.75	12.2	35.94	8.5

Table 45: Economic Breakeven Points for Methane Recovery Facilities

Facility	Head Size Breakeven Point for Each Scenario					
	#1	#2	#3	#4	#5	#6
Farrow to Finish[a]	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
Finishing[b]	>20,000	>20,000	4,792	13,949	>20,000	1,856
Tie Stall –Plug Flow[c]	>5,000	>5,000	222	>5,000	>5,000	1,090
Tie Stall –Complete Mix	>5,000	>5,000	148	>5,000	>5,000	314
Free Stall –Plug Flow	>5,000	>5,000	234	>5,000	>5,000	1,230
Free Stall –Complete Mix	>5,000	>5,000	148	>5,000	>5,000	330

[a] animal number represents number of sows on site and does not include nursery, grower, finisher, or boars

[b] number of finishing pigs only

[c] number represents lacatating cows on-site

Table 46: Importance Rankings of Methane Meeting Participant and Producer Opinions of the Livestock Methane Recovery

Barrier, Issue, or Opportunity	Meeting Participant Average Rank[1]
Low rate of economic return on methane recovery facilities	2.6
Interconnection difficulties with utilities/low rate for sale of excess electricity	3.5
Few turnkey systems developed/lack of contractor knowledge in construction of methane recovery facilities	3.6
Further development of technology for on-farm methane recovery	4.6
Lack of technical information and assistance	4.7
Difficulties obtaining financing for a methane recovery system	4.9
Public awareness of the generation/utilization of methane from livestock facilities	5.9
Lack of cooperation between various organizations (government, nonprofit, etc) to promote and educate on the use of on-farm methane recovery	6.2

[1]The average of all of the responses in the category between 1 (greatest barrier) to 8 (least important barrier).

Table 47: Policy Scenarios for the Fossil Fuel Displacement Situations

Scenario	Policy Scenario Description
1	Utilize 100% of Iowa's manure resources with no losses and no regard to economic feasibility from Appendix A. This is done to give the reader an idea of the energy that resides in the manure resource.
2	Utilize 100% of the dairy and swine manure resources in Iowa from data in Appendix A. Dairy and swine manure, due to management and physical characteristics, has the highest potential for use with methane recovery technologies.
3	Utilize 50% of the dairy and swine manure resources in Iowa from data in Appendix A. Dairy and swine manure, due to management and physical characteristics, has the highest potential for use with methane recovery technologies.
4	Utilize 25% of the dairy and swine manure resources in Iowa from data in Appendix A. Dairy and swine manure, due to management and physical characteristics, has the highest potential for use with methane recovery technologies.
5	Energy recovery from scenario #3 where the electricity rate doubles from the present rate of 6 cents per kwh to 12 cents per kwh for swine and dairy manure at 100% utilization.
6	Energy recovery from scenario #6 where economic incentives, such as low interest loans, are used to stimulate the development and implementation of methane technologies for dairy and swine manure at 100% utilization.

Table 48: Quantities of Fossil Fuels Displaced by Livestock Methane Recovery

Policy Scenario	Quantity of Fossil Fuel Needed if Used to Completely Replace the Electricity Generated from Methane[1]			
	Electricity Equivalent[2] (MWH)	Coal (short tons)	#2 Fuel Oil (barrels)	Natural Gas/LNG (million cubic ft)
1	2,820,108.8	1,394,932.1	5,472,001.3	30,998.5
2	1,384,532.1	684,841.7	2,686,478.4	15,218.7
3	692,266.0	342,420.9	1,446,803.0	7,609.4
4	346,133.0	171,210.4	671,619.6	3,804.7
5	153,423.8	75,889.2	297,696.0	1,686.4
6	230,932.8	114,228.0	448,090.6	2,538.4

[1]Conversions from Perry's Chemical Engineering Handbook, 1984

[2]To calculate electricity equivalent the methane production from each scenario is converted to heat and then electricity assuming a power plant overall thermal efficiency of 30%.

Appendix B

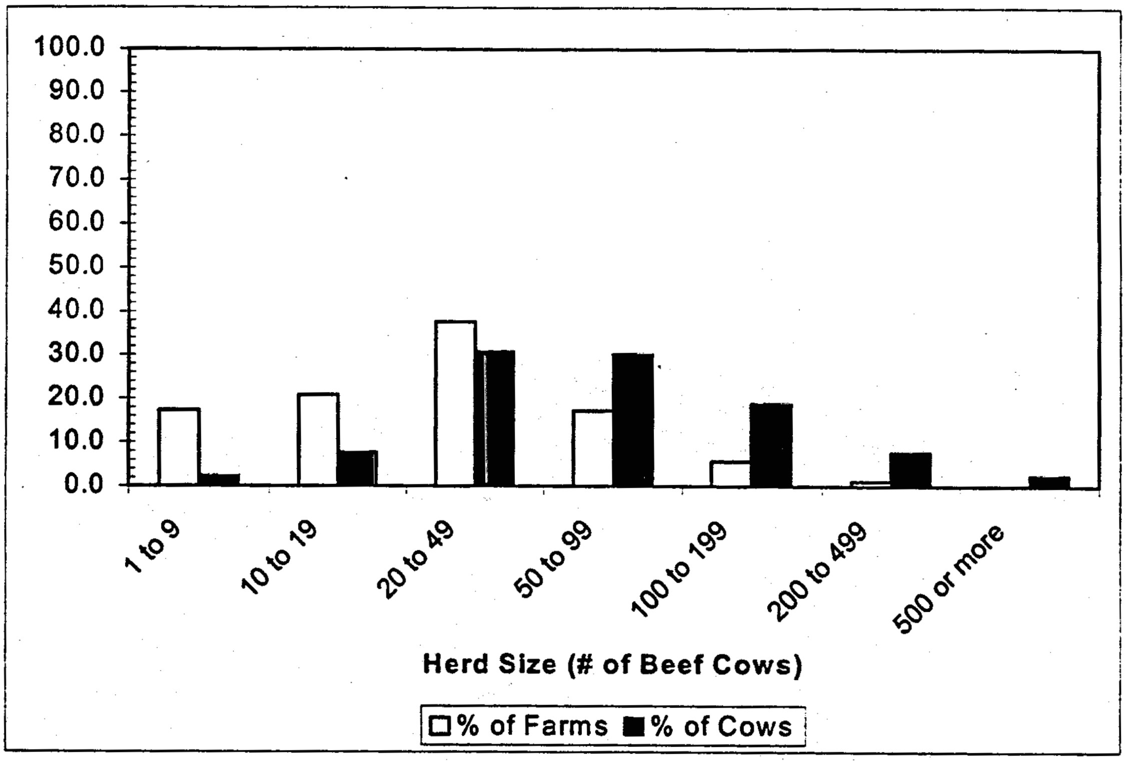


Figure 1: Farm and Inventory Based on USDA Beef Herd Classifications

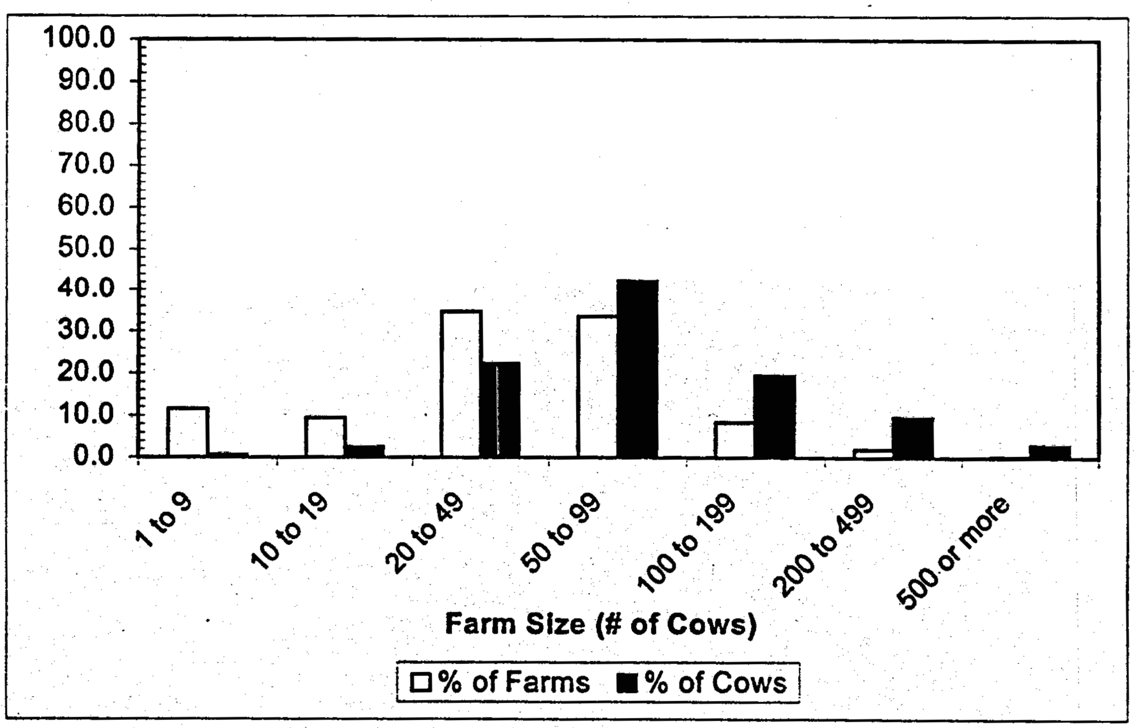


Figure 2: Farm and Inventory Based on USDA Dairy Herd Classifications

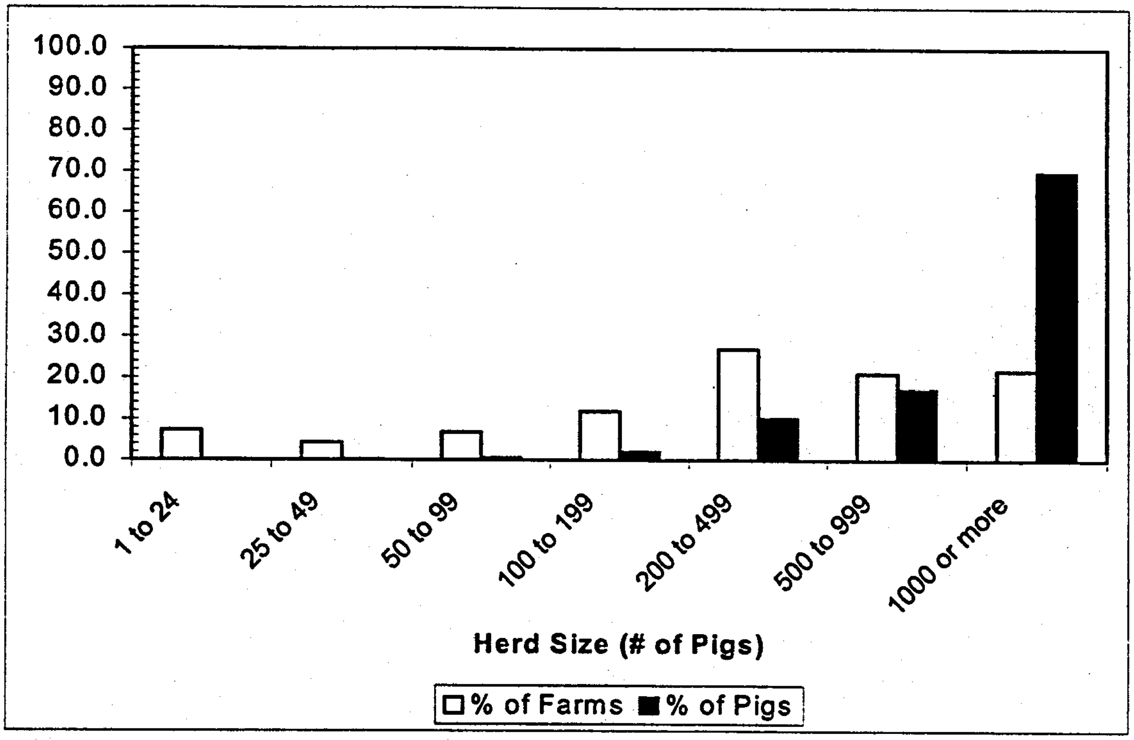


Figure 3: Swine Herd Profiles for Iowa

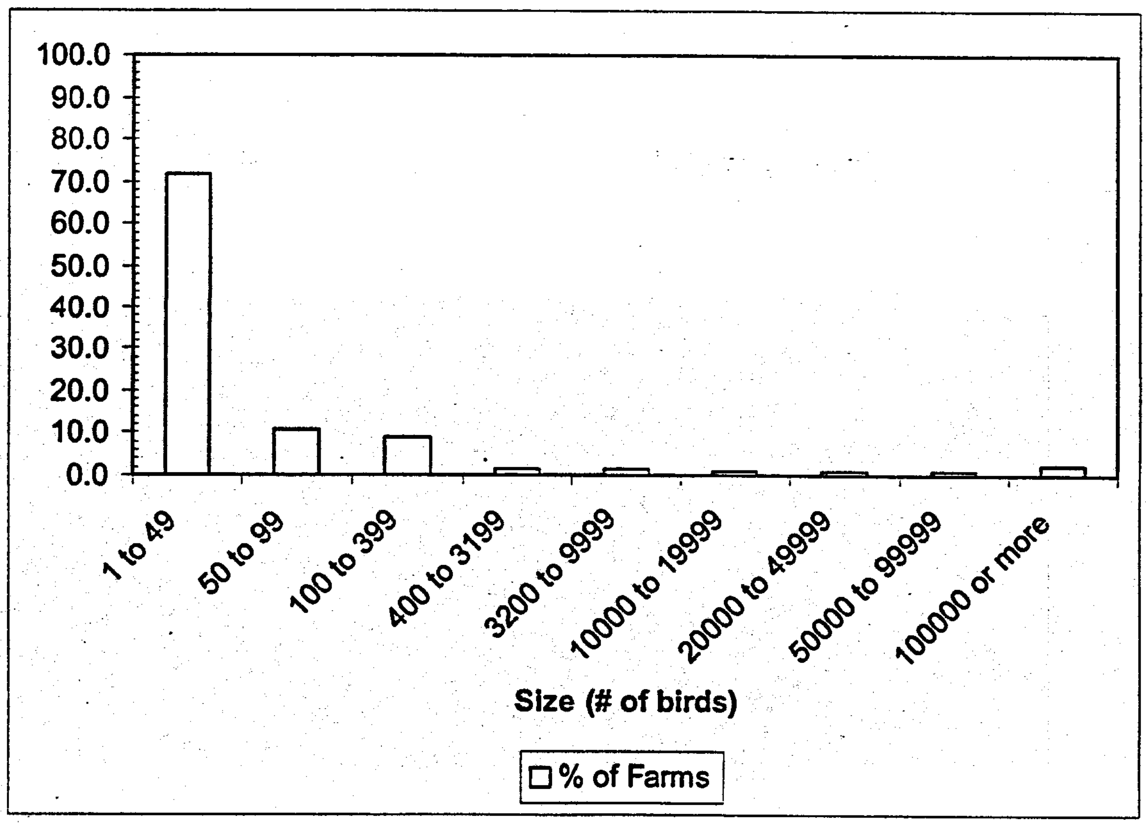


Figure 4: Profile for Poultry Layer Farm Sizes

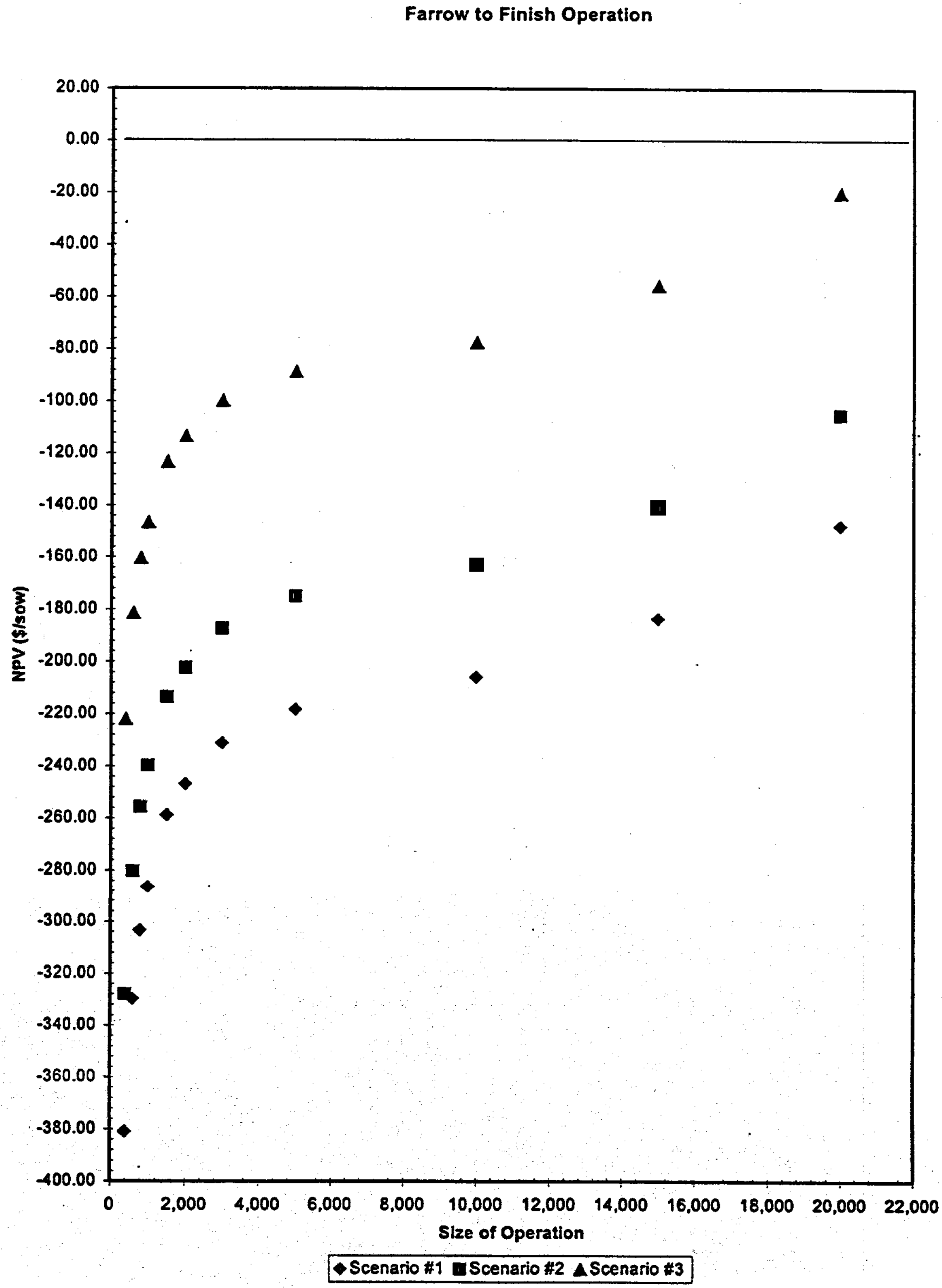


Figure 5: Net Present Value of Swine Farrow to Finish Operation Digester

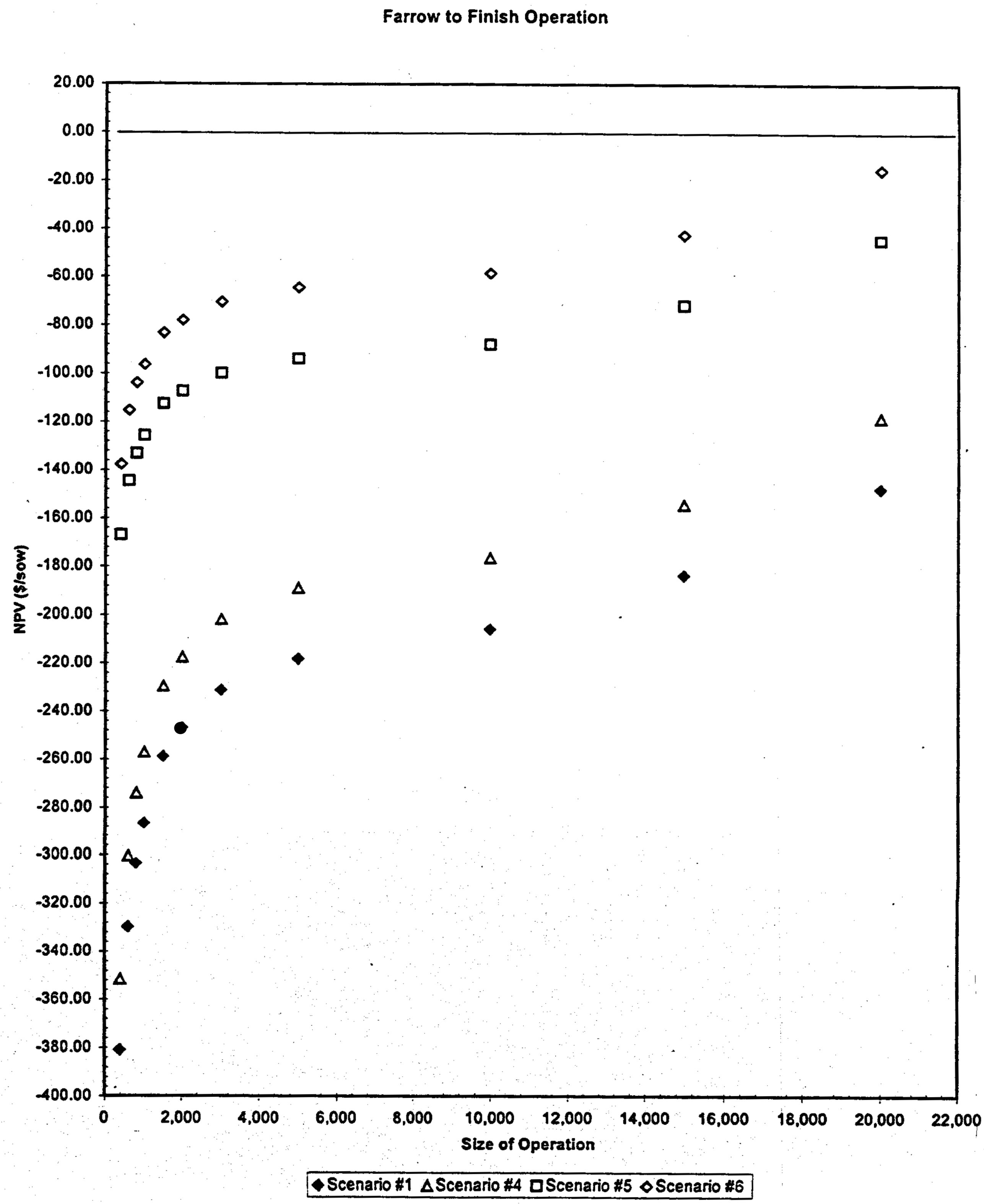


Figure 6: Net Present Value of Swine Farrow to Finish Operation Digester

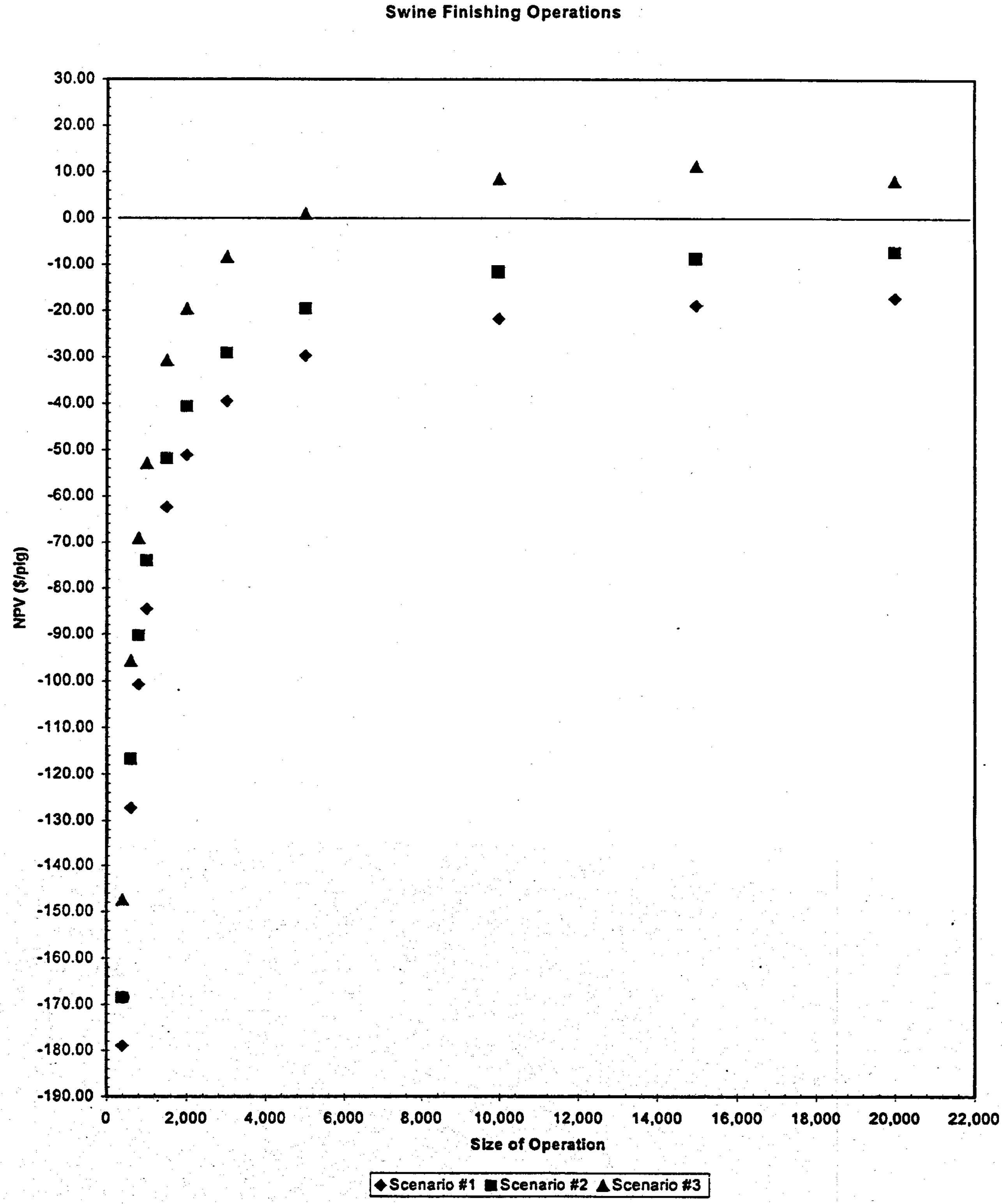


Figure 7: Net Present Value of Finishing Operation Digester

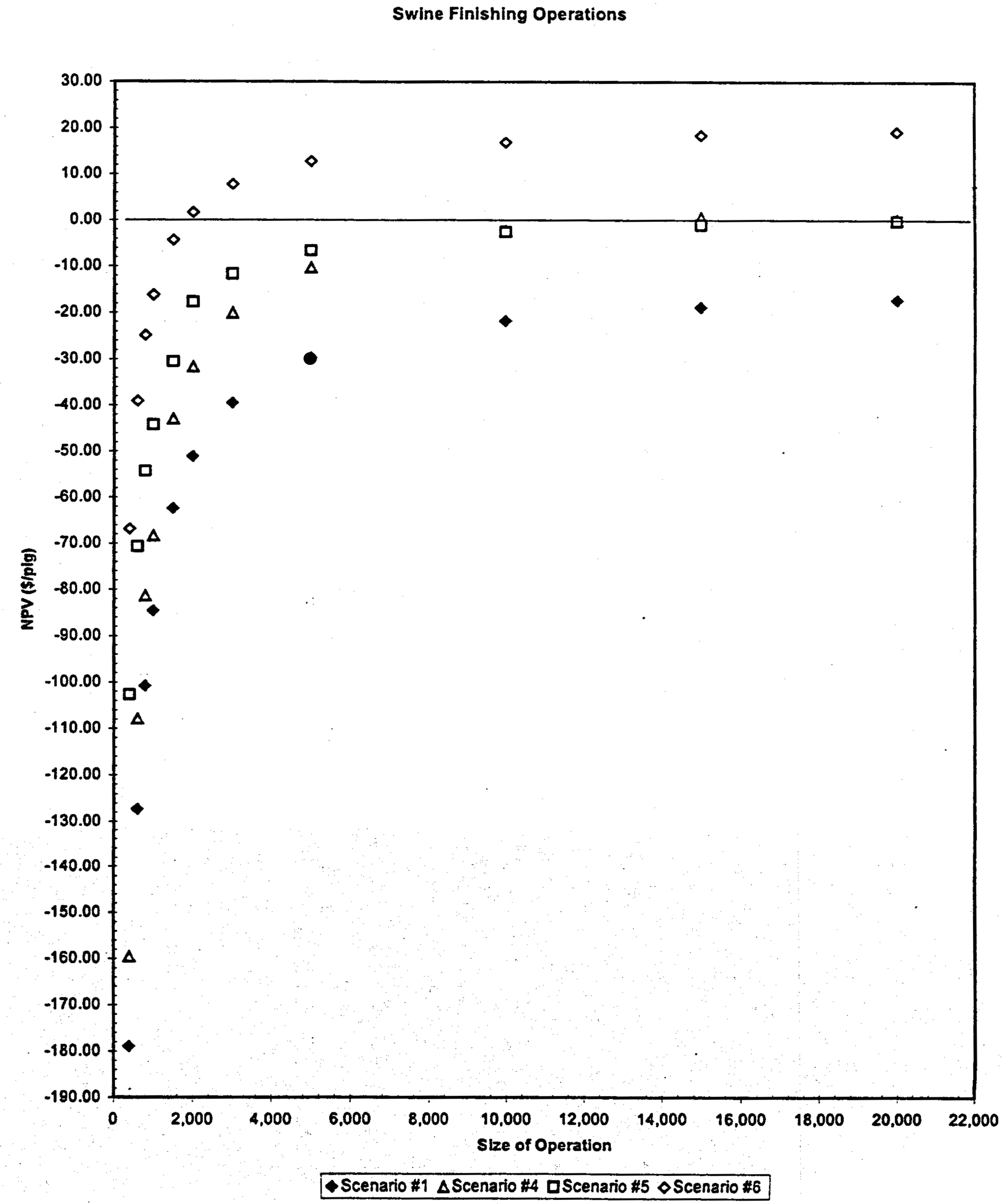


Figure 8: Net Present Value for Finishing Operation Digester

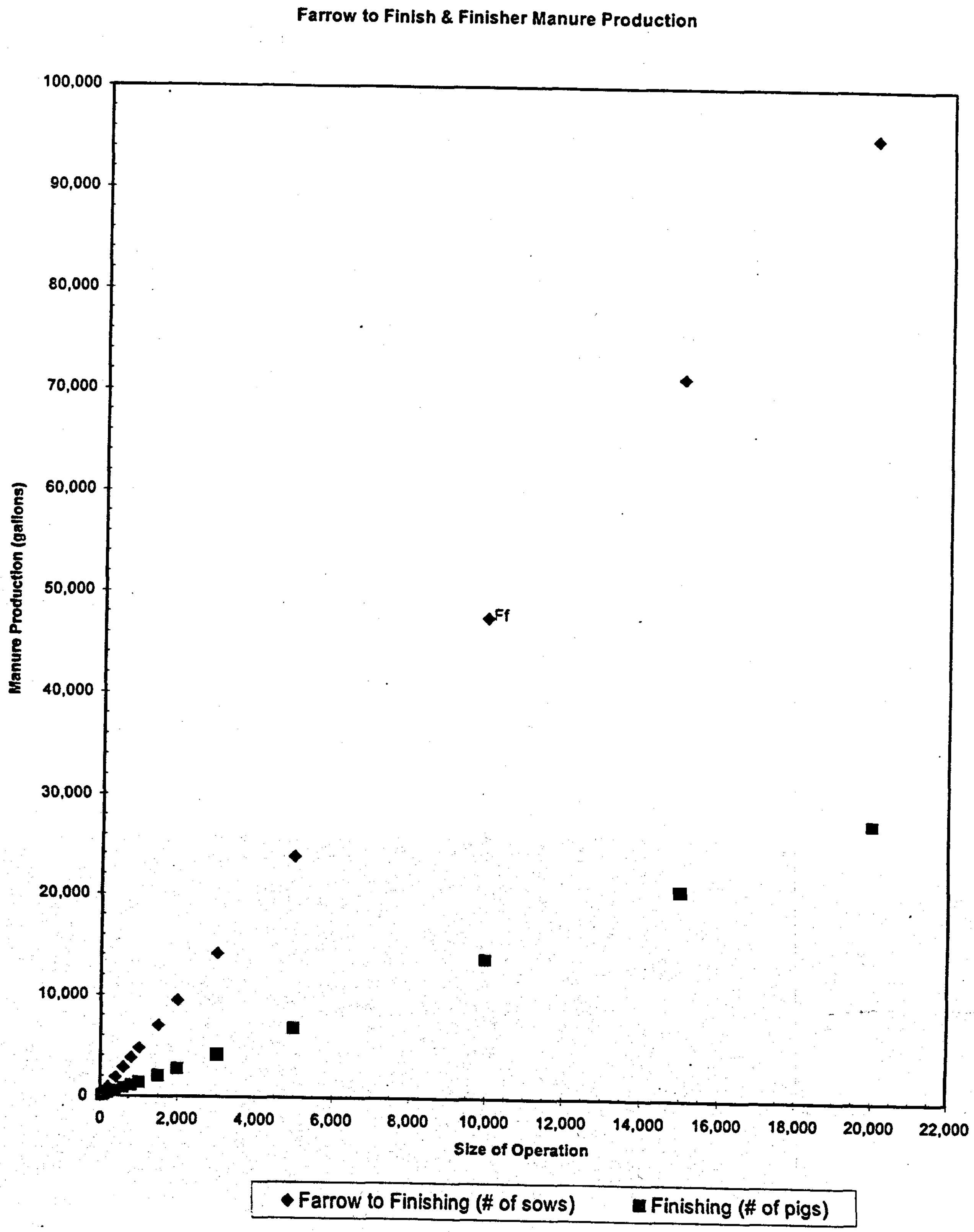


Figure 9: Farrow to Finish and Finisher System Manure Production

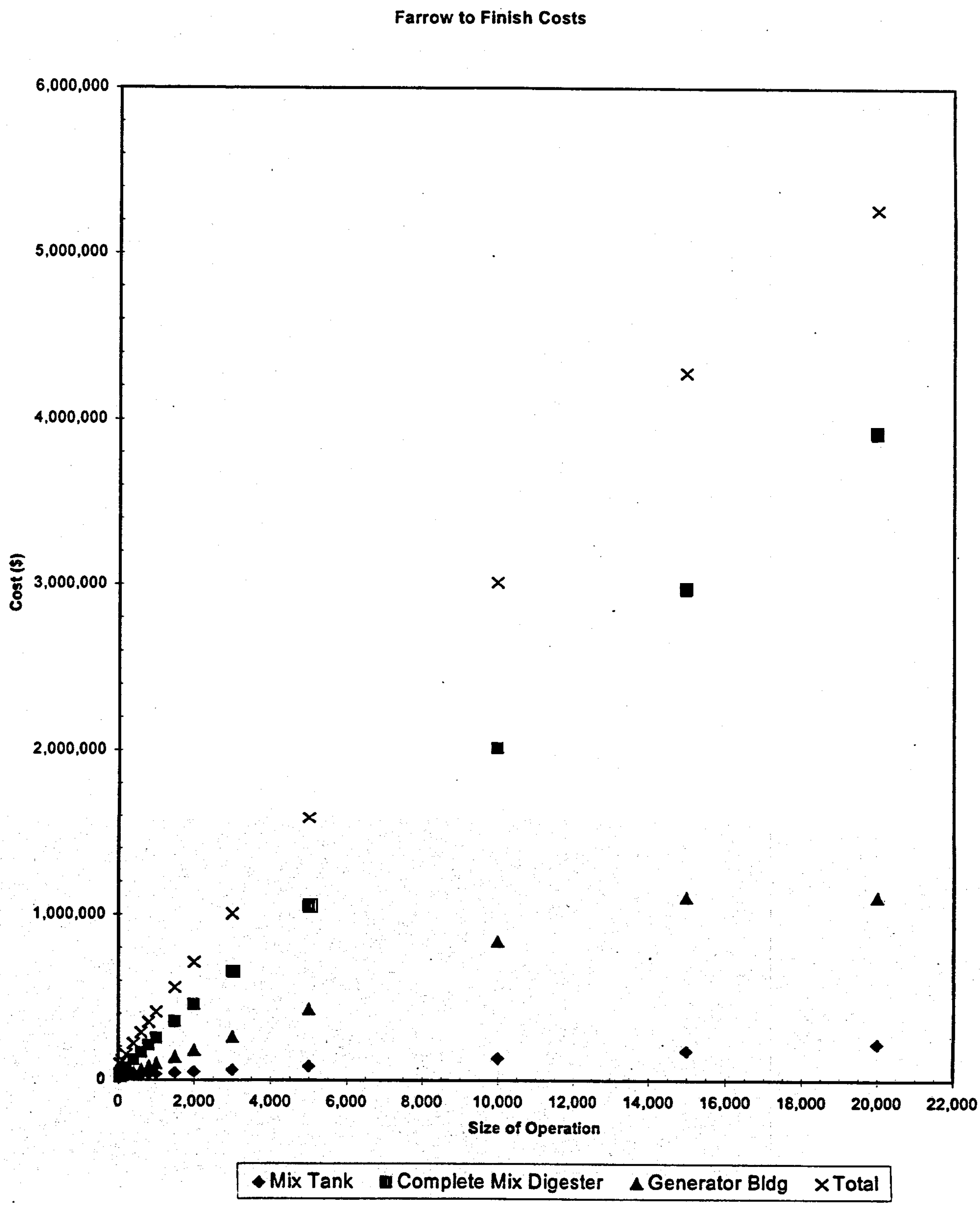


Figure 10: Farrow to Finish Operation Component and Total Costs

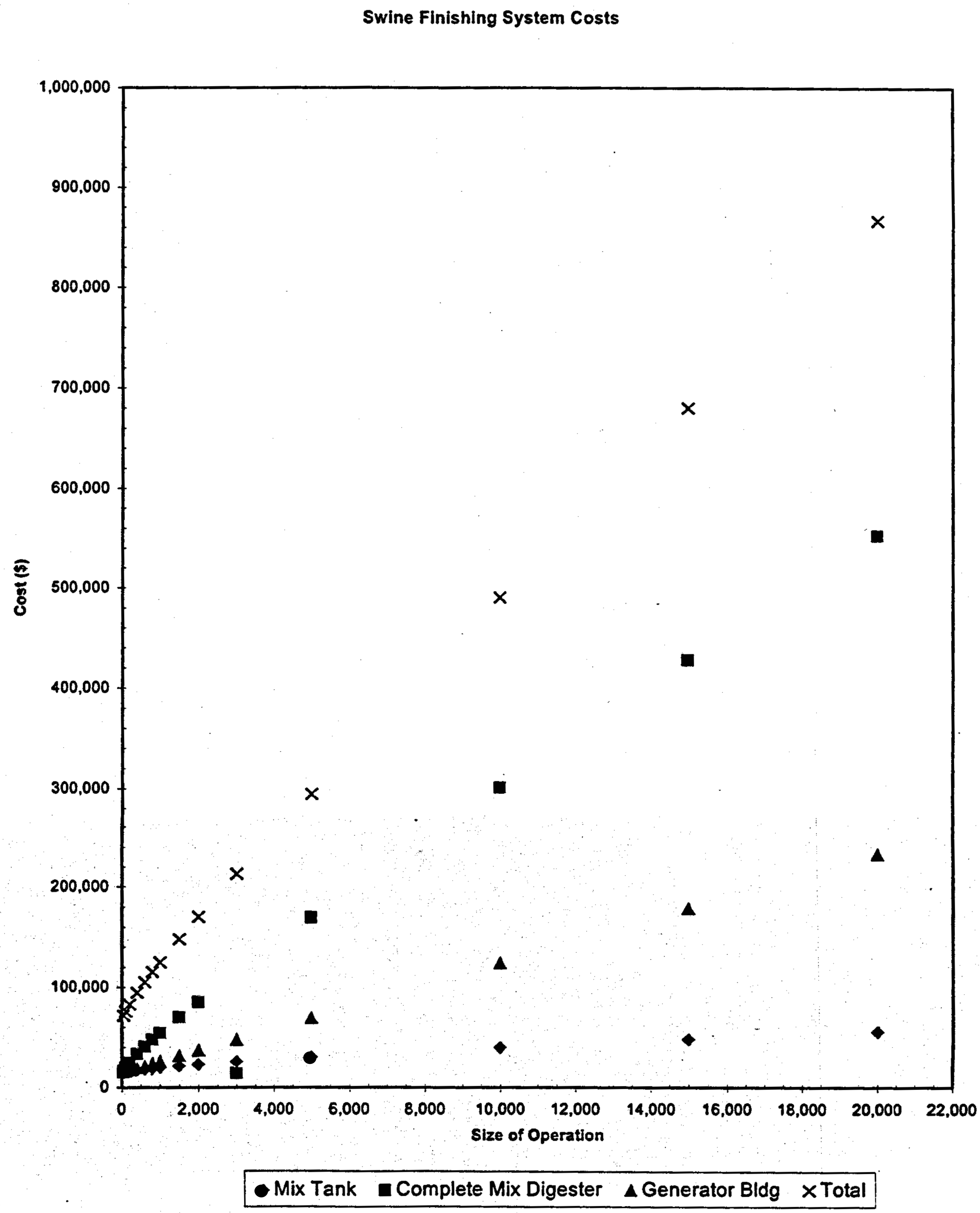


Figure 11: Finishing Operation Component and Total Costs

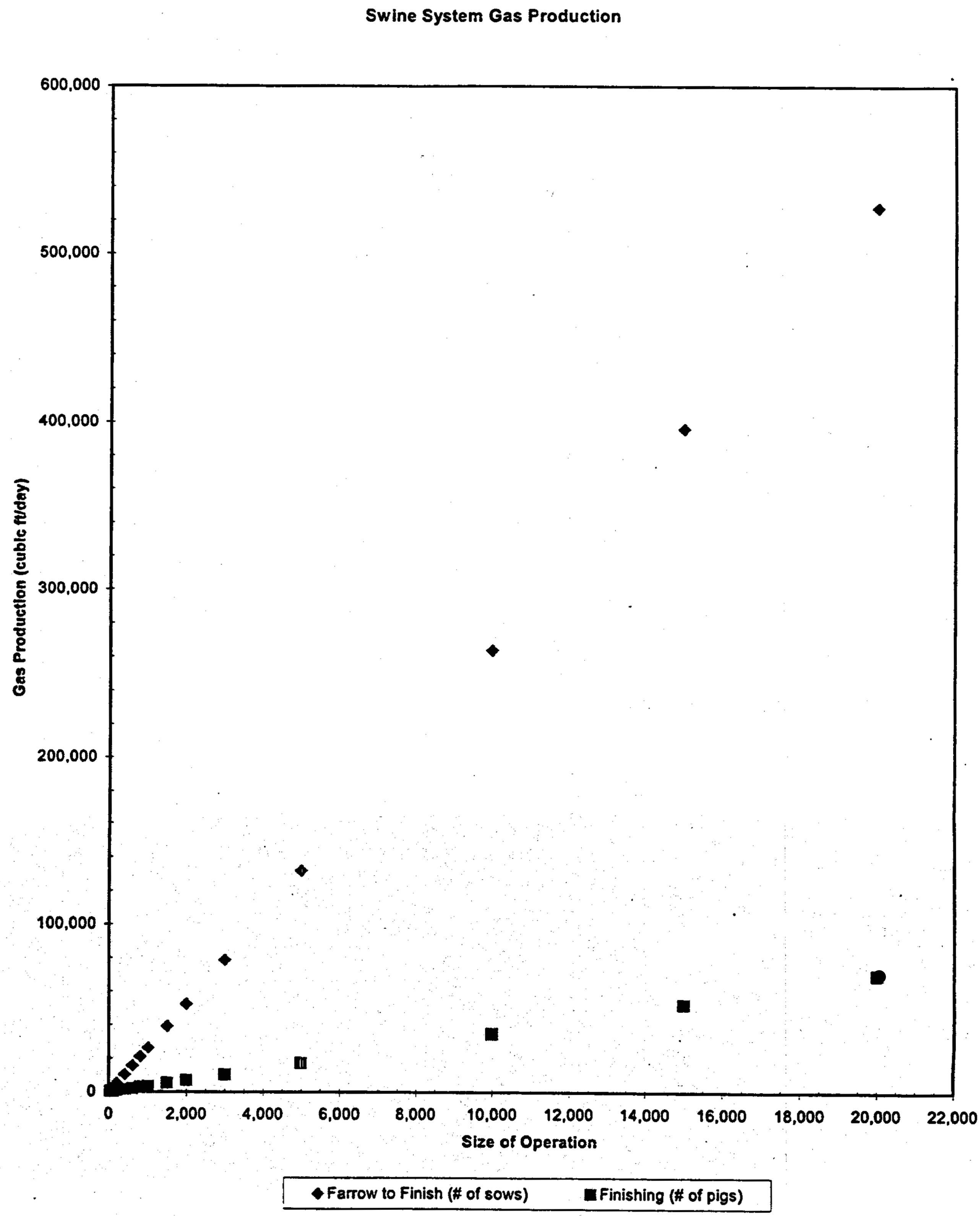


Figure 12: Farrow to Finish and Finishing System Gas Production

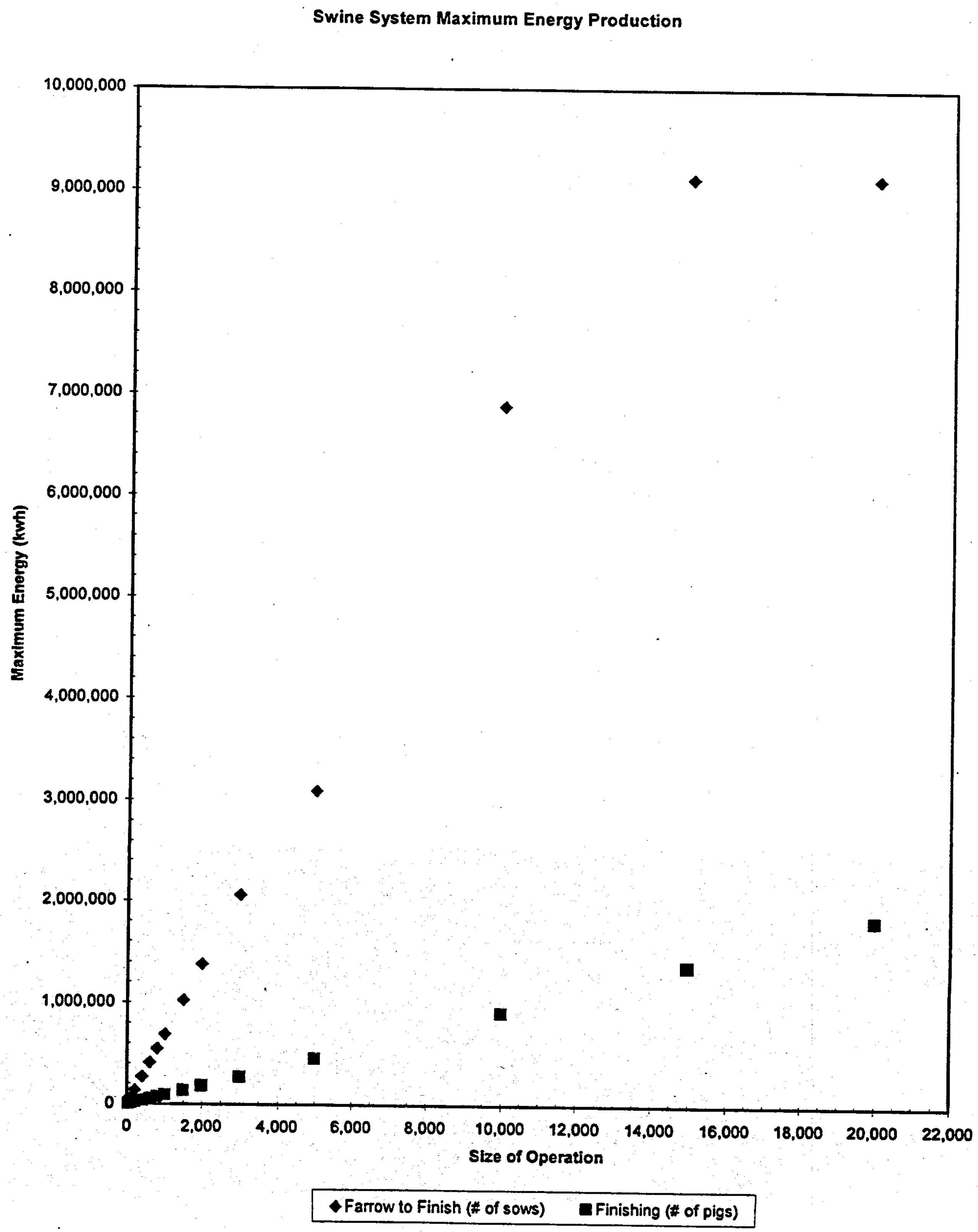


Figure 13: Swine Farrow to Finish and Finishing Maximum Energy Production

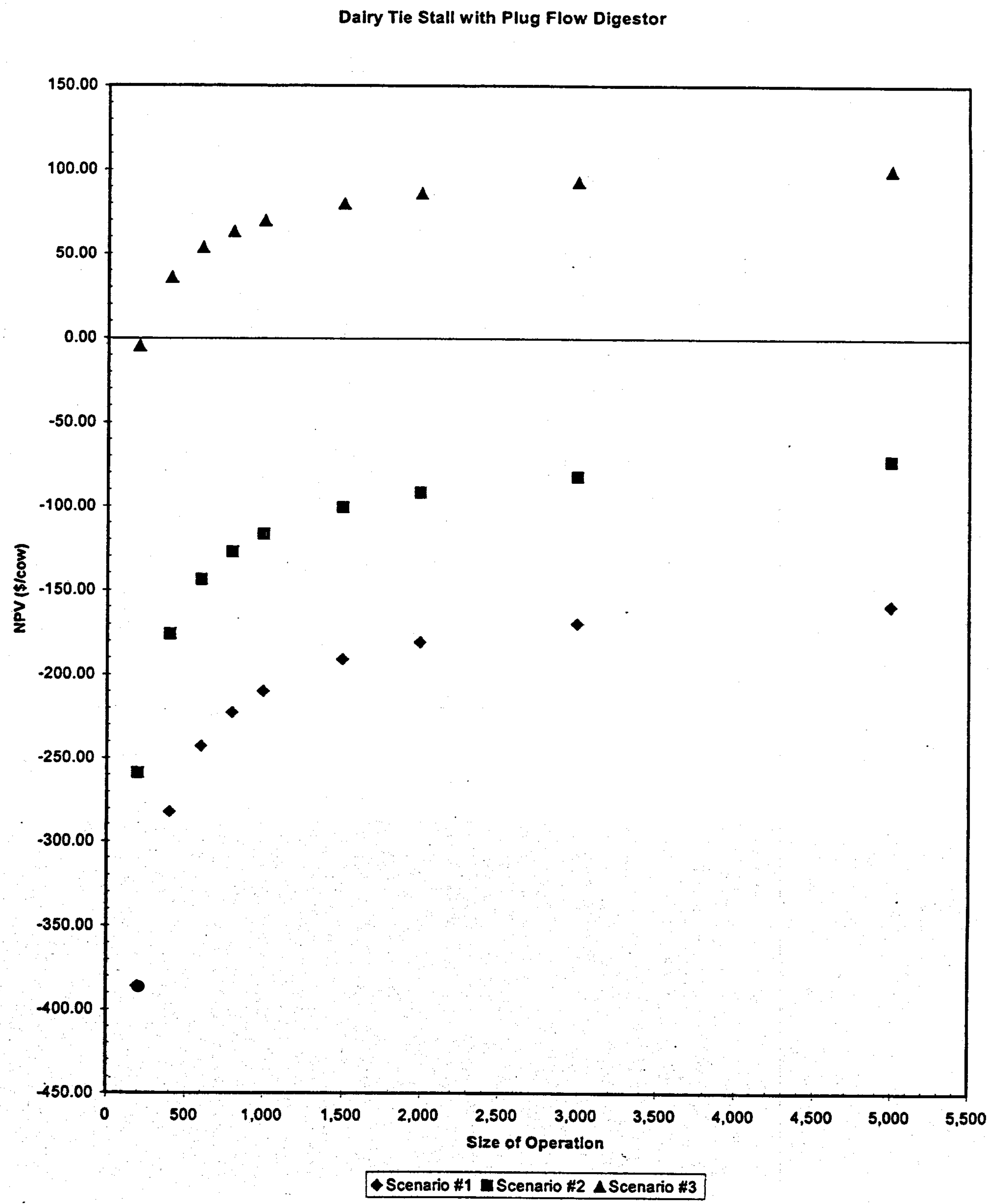


Figure 14: Net Present Value for Dairy Tie Stall with Plug Flow Digester

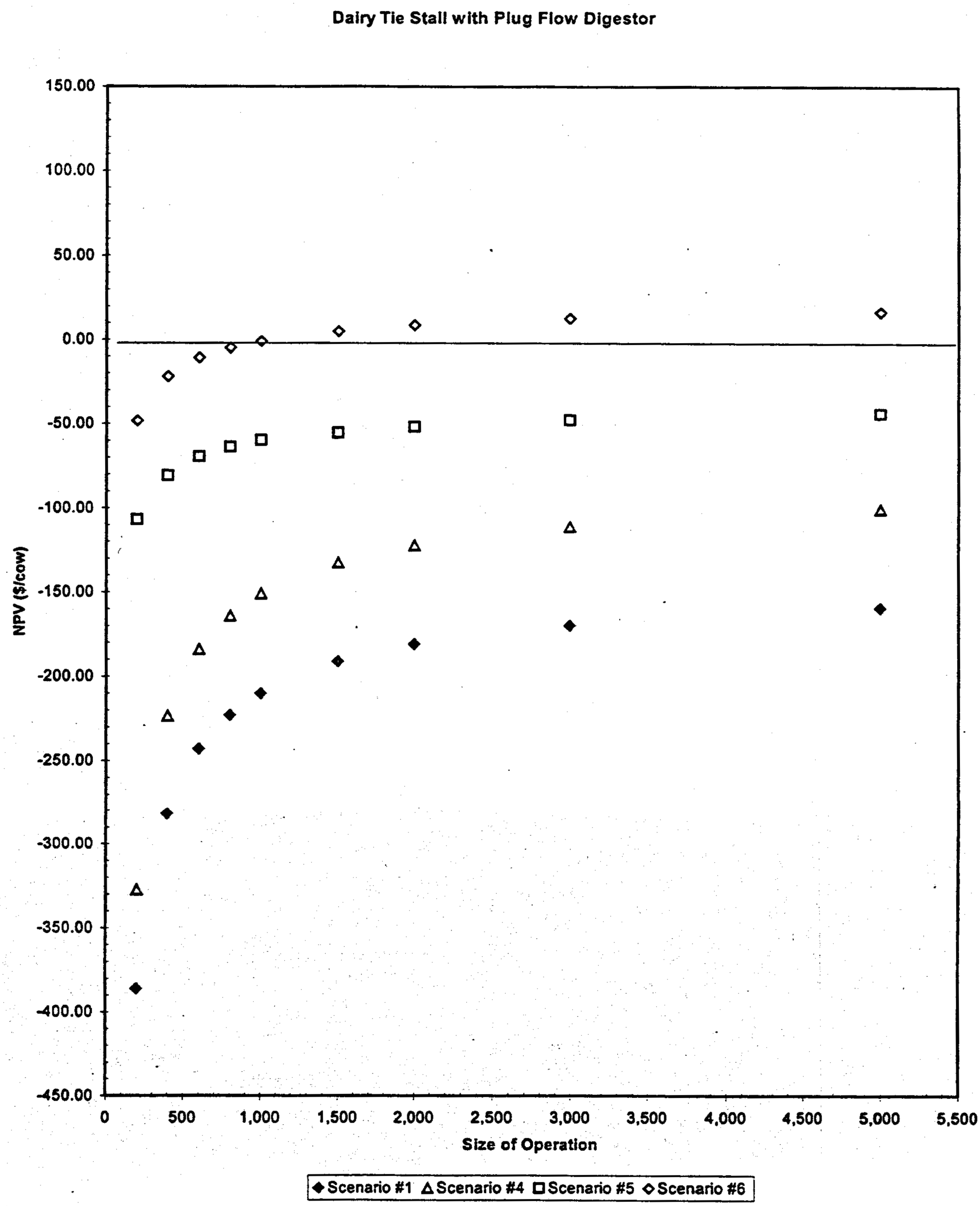


Figure 15: Net Present Value Dairy Tie Stall with Plug Flow Digester

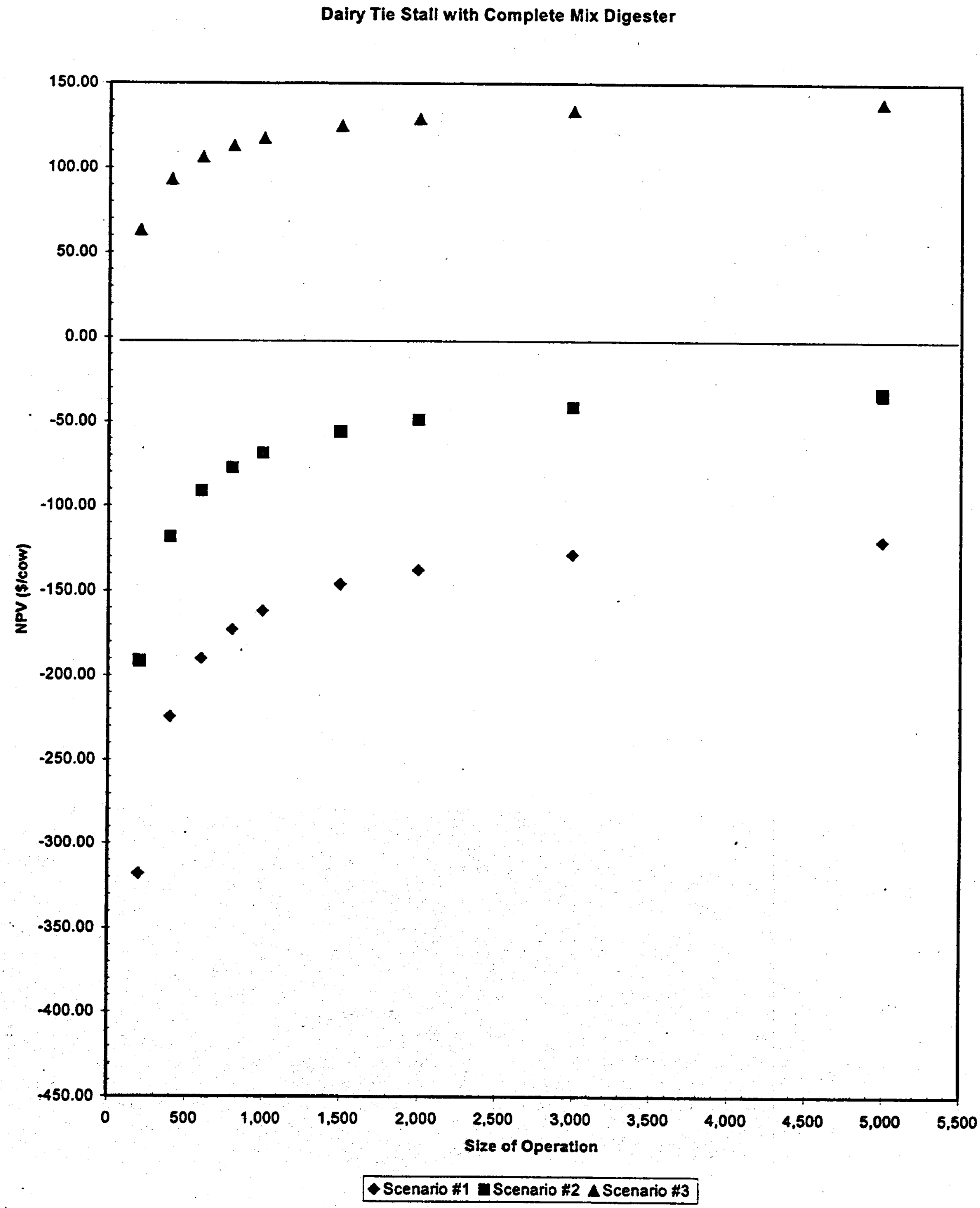


Figure 16: Net Present Value for Dairy Tie Stall with Complete Mix Digester

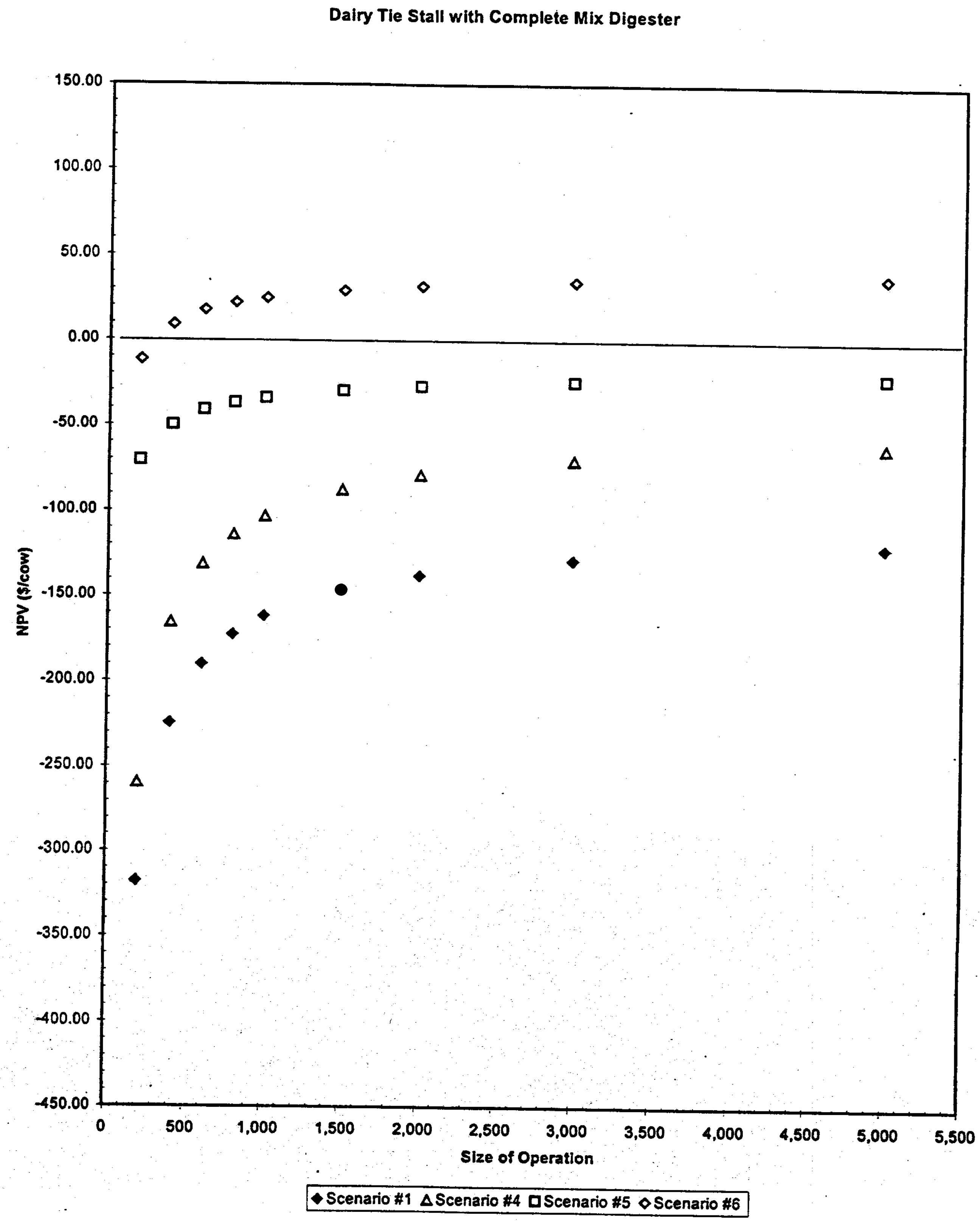


Figure 17: Net Present Value for Dairy Tie Stall with Complete Mix Digester

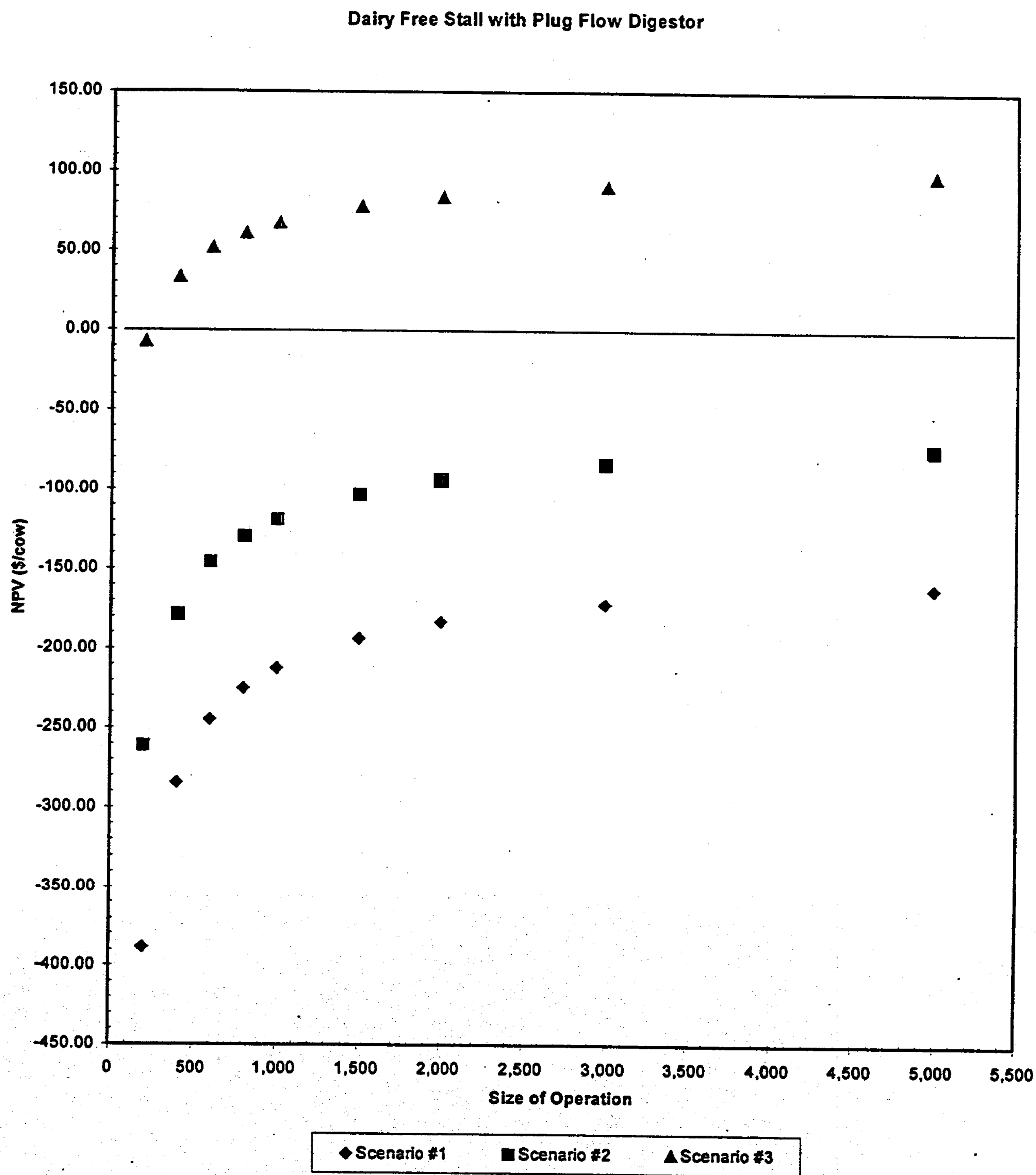


Figure 18: Net Present Value for Dairy Free Stall with Plug Flow Digester

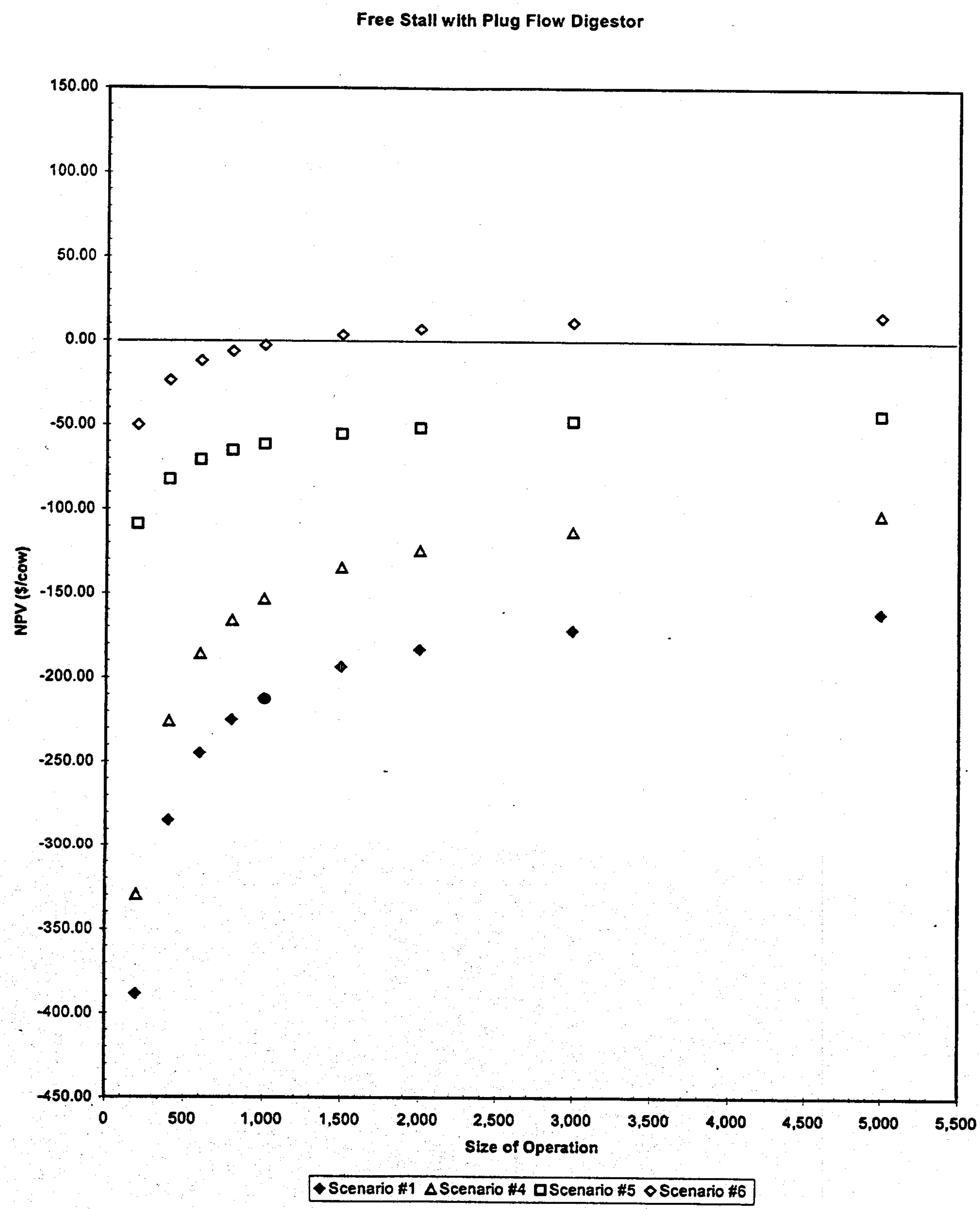


Figure 19: Net Present Value for Dairy Free Stall with Plug Flow Digester

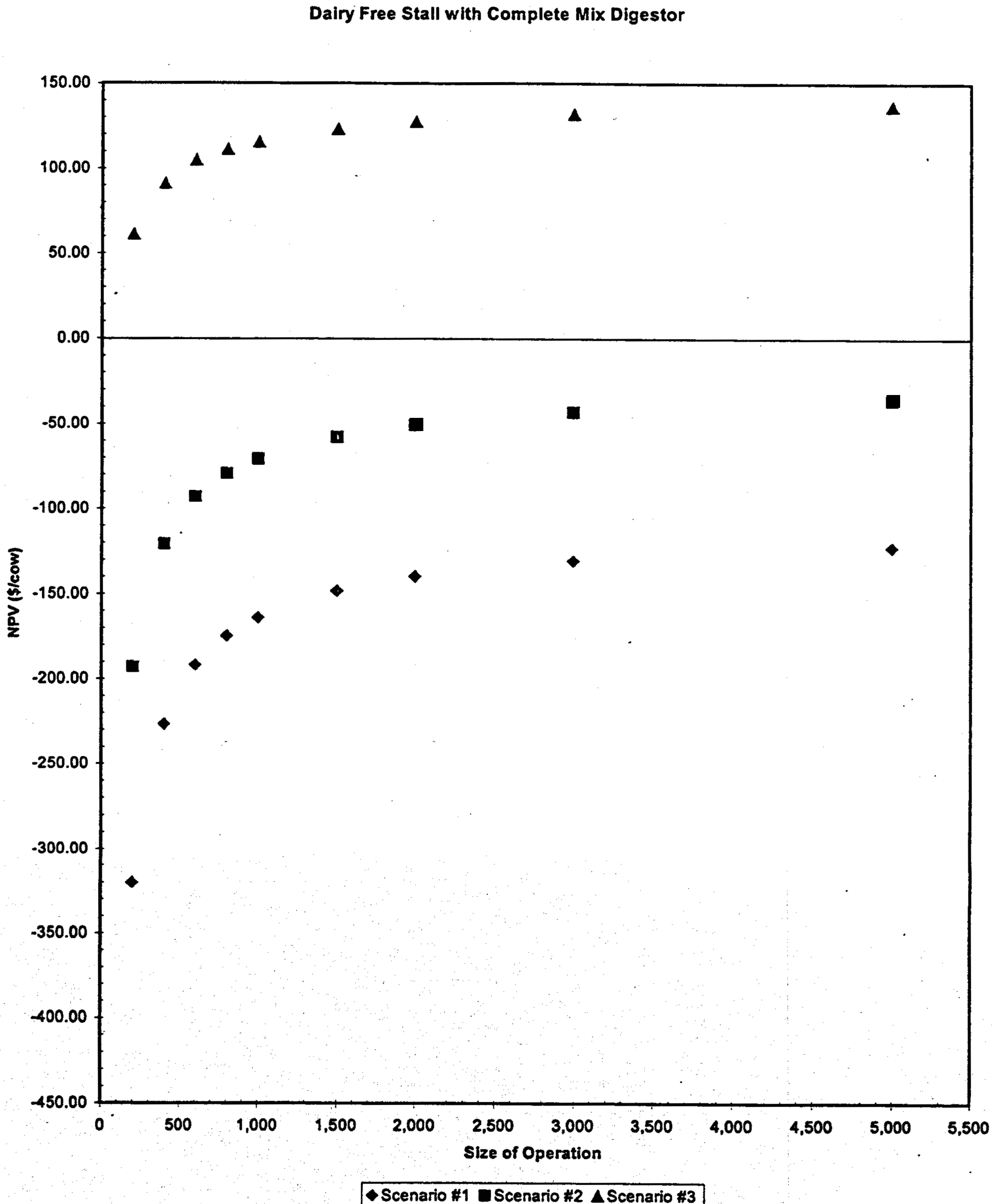


Figure 20: Net Present Value for Dairy Free Stall with Complete Mix Digester

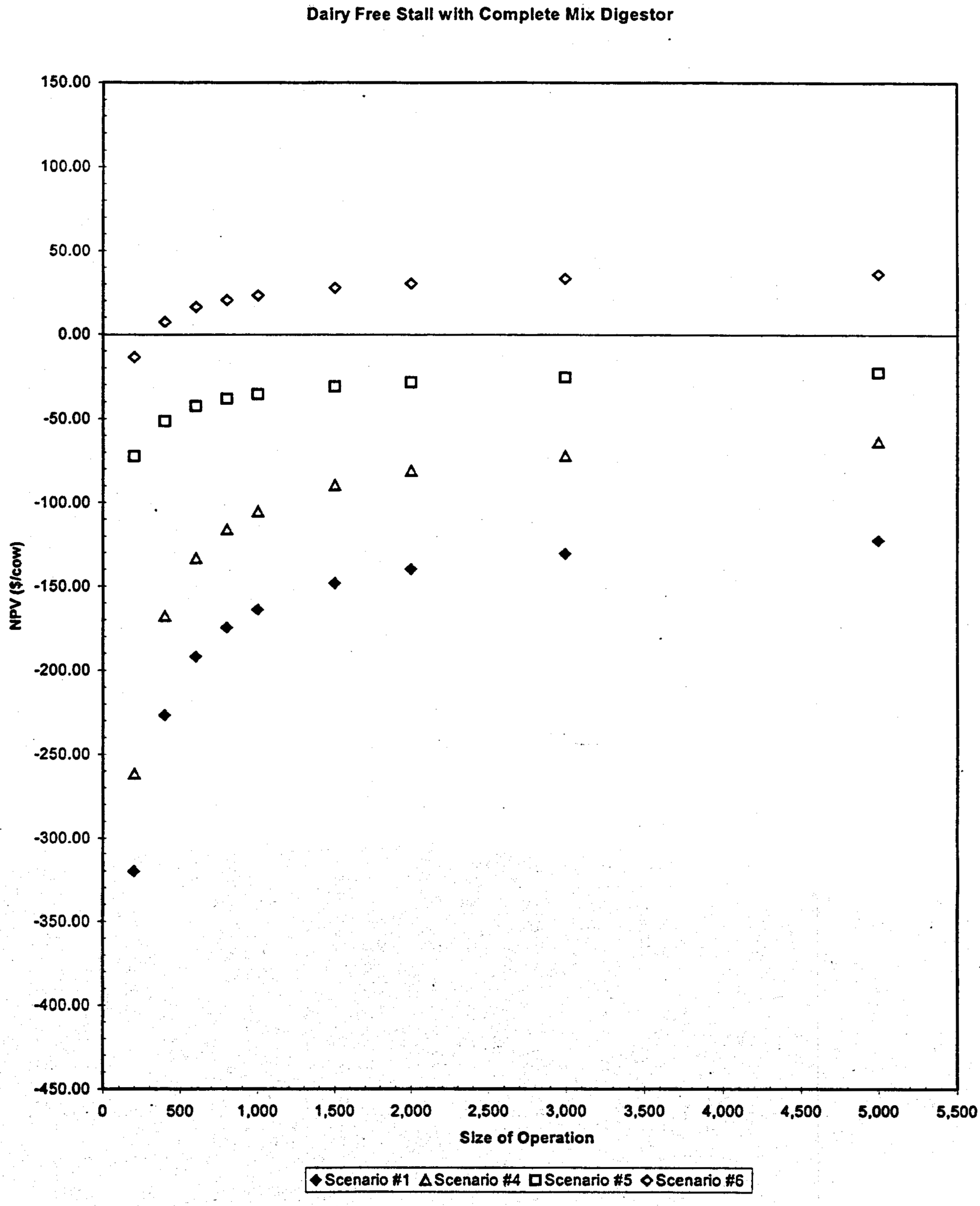


Figure 21: Net Present Value for Dairy Free Stall with Complete Mix Digester

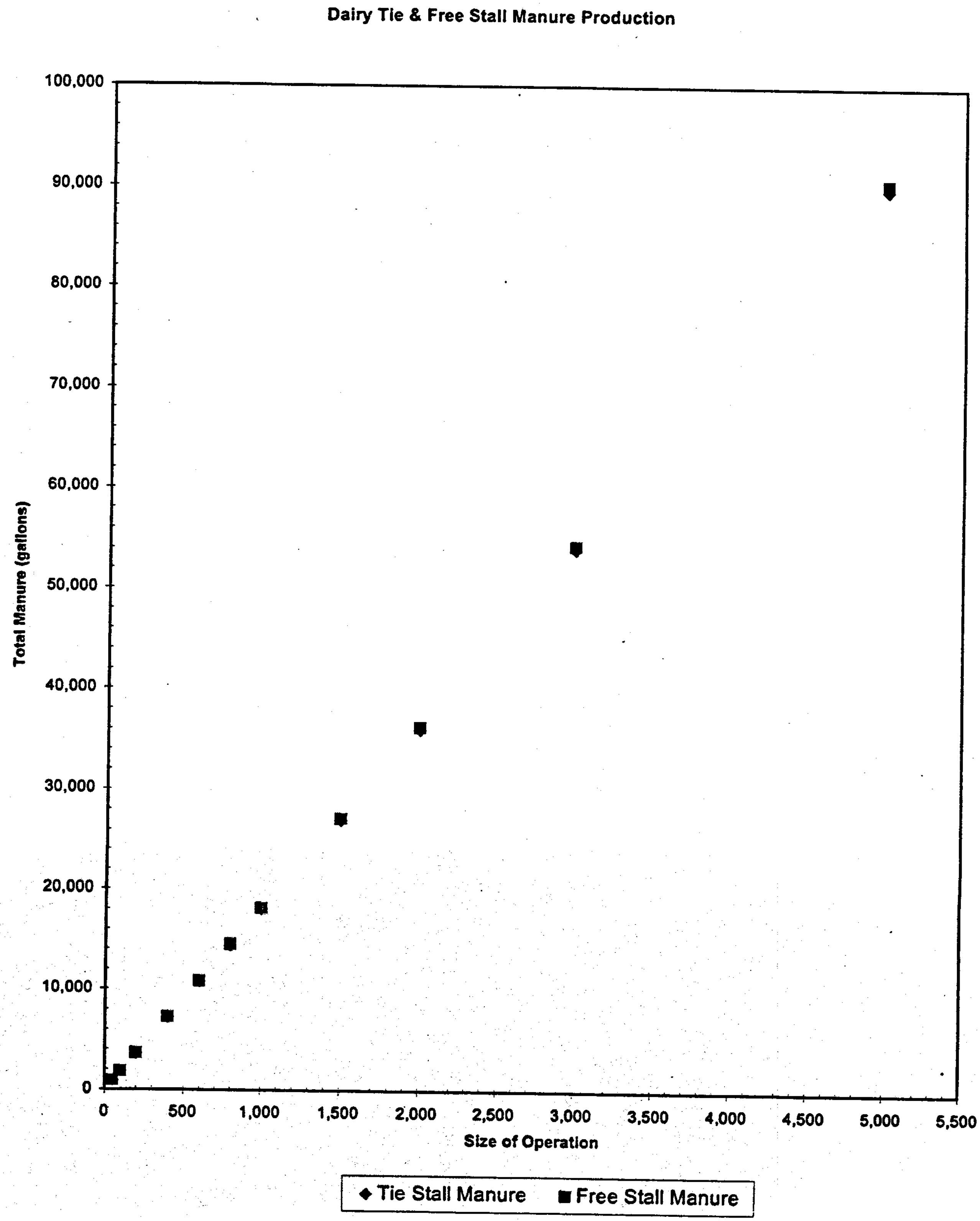


Figure 22: Diary Tie and Free Stall Manure Production

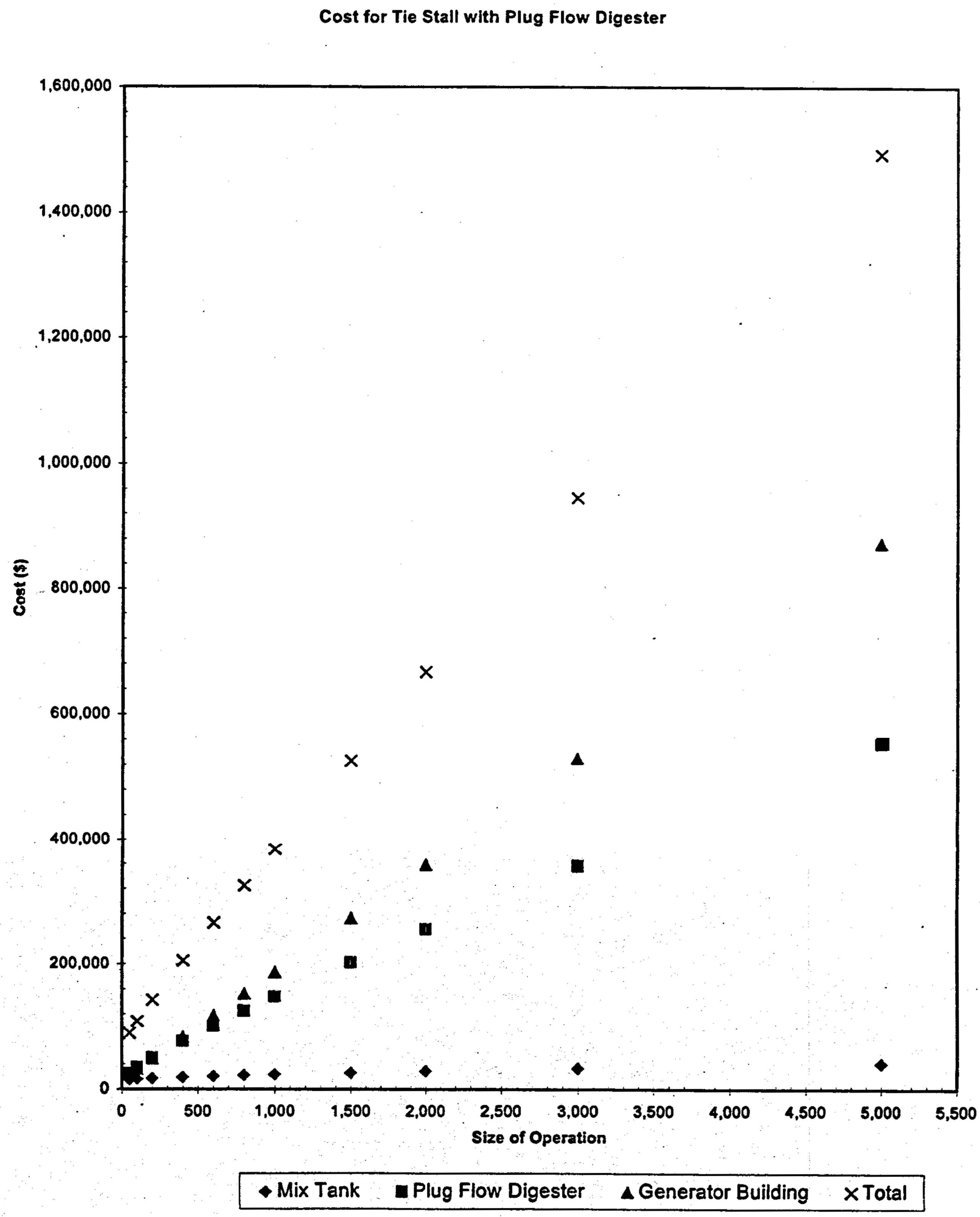


Figure 23: Dairy Tie Stall Plug Flow Digester Component and Total Costs

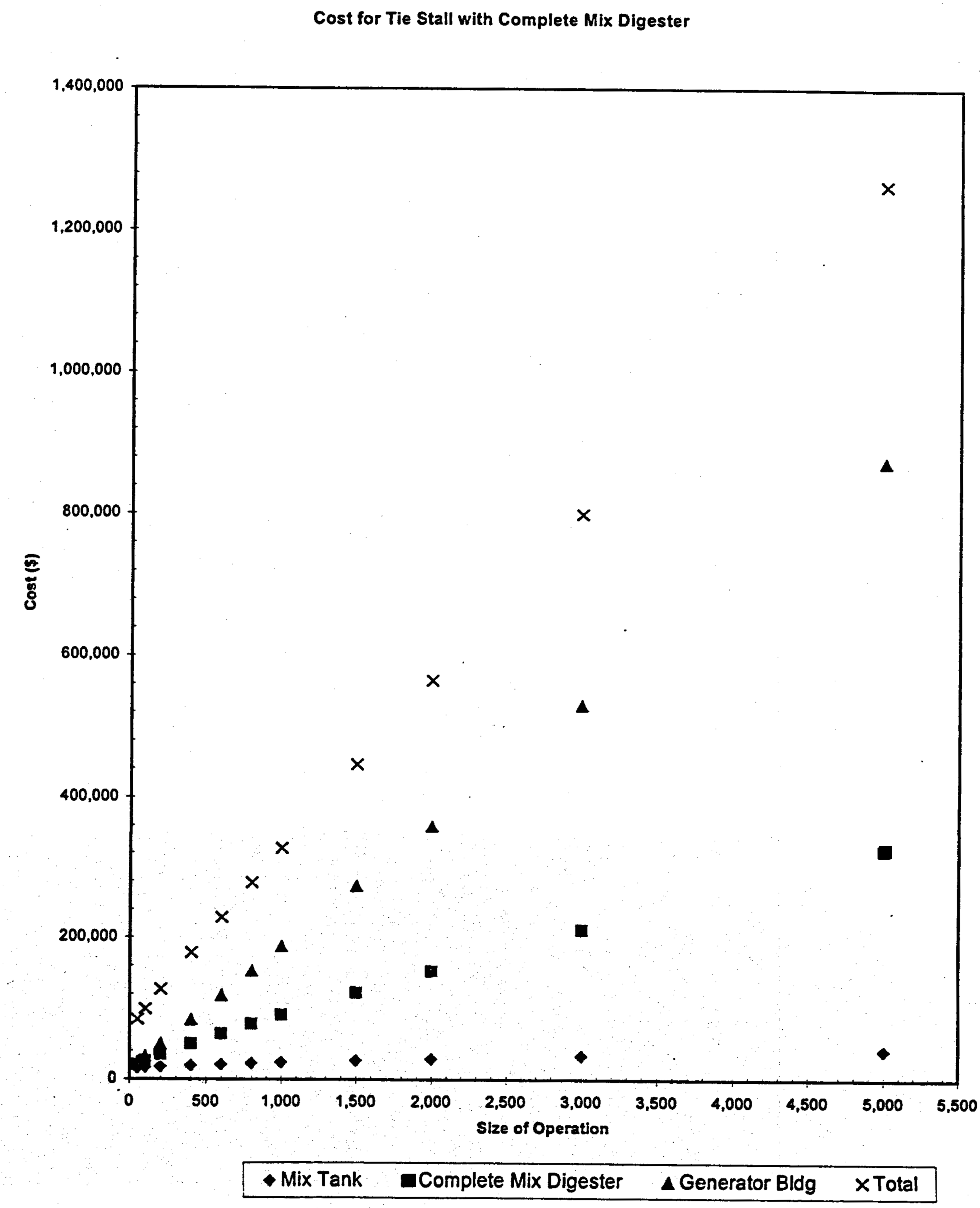


Figure 24: Dairy Tie Stall Complete Mix Digester Component and Total Costs

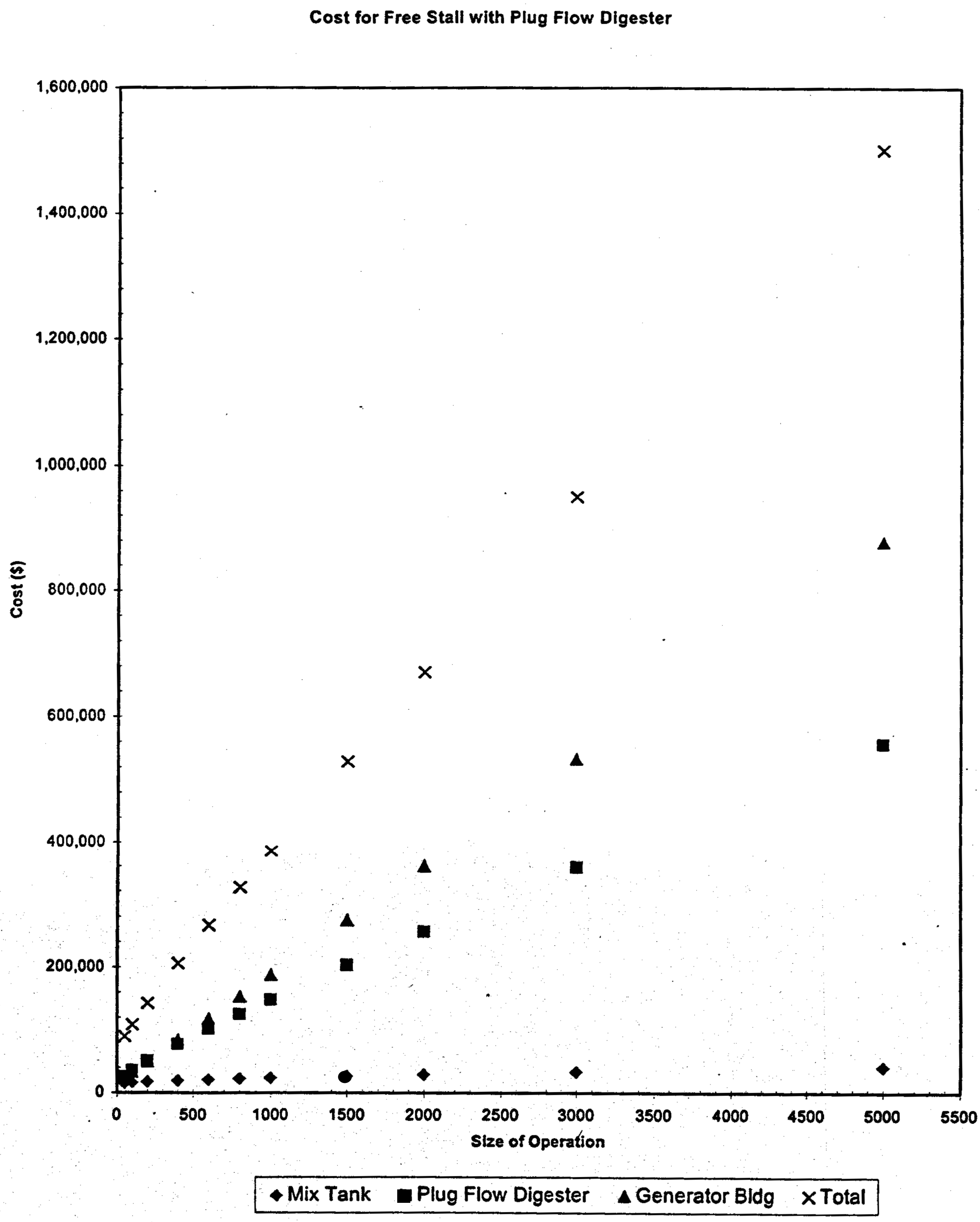


Figure 25: Dairy Free Stall Plug Flow Digester Component and Total Costs

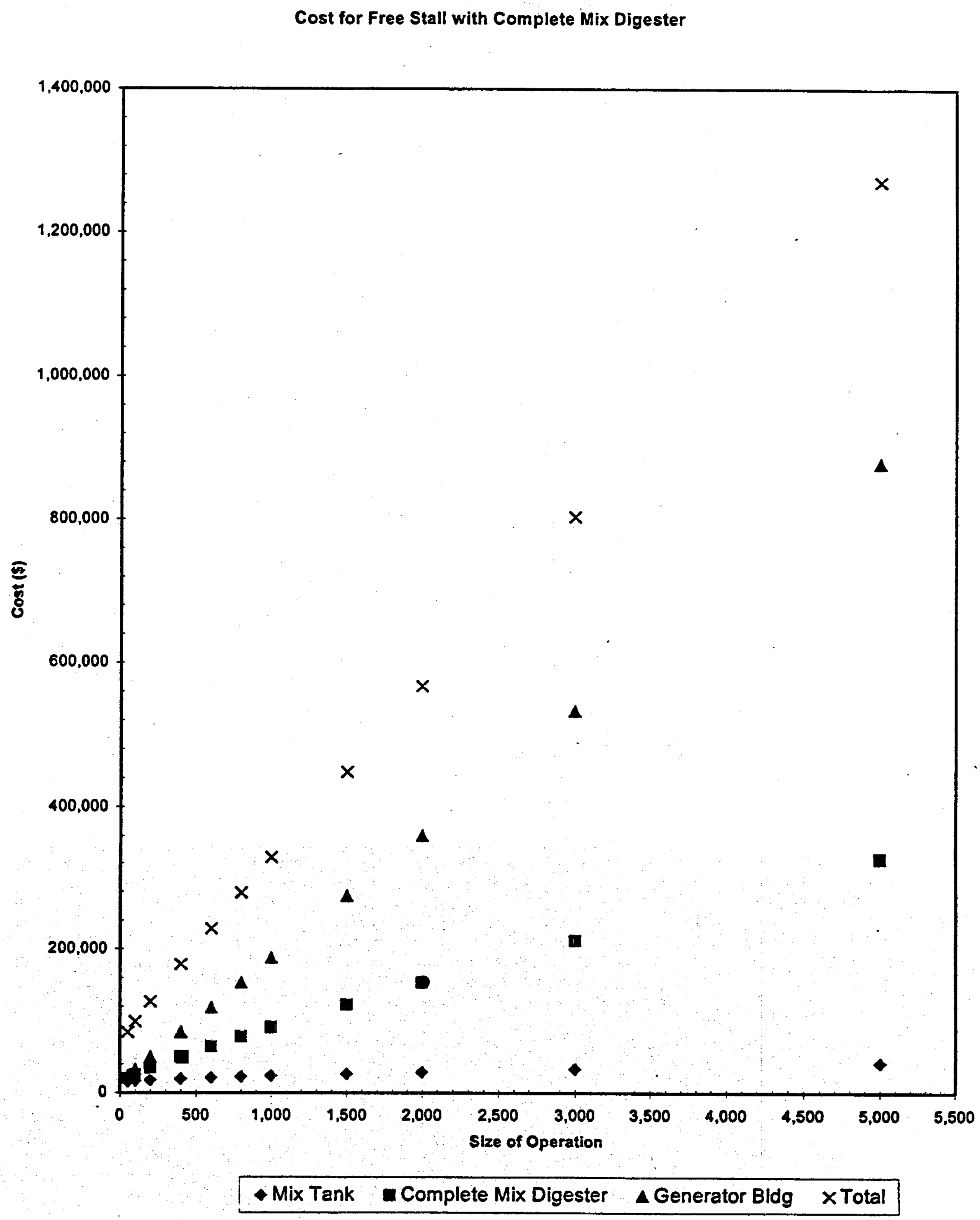


Figure 26: Dairy Free Stall Complete Mix Digester Component and Total Costs

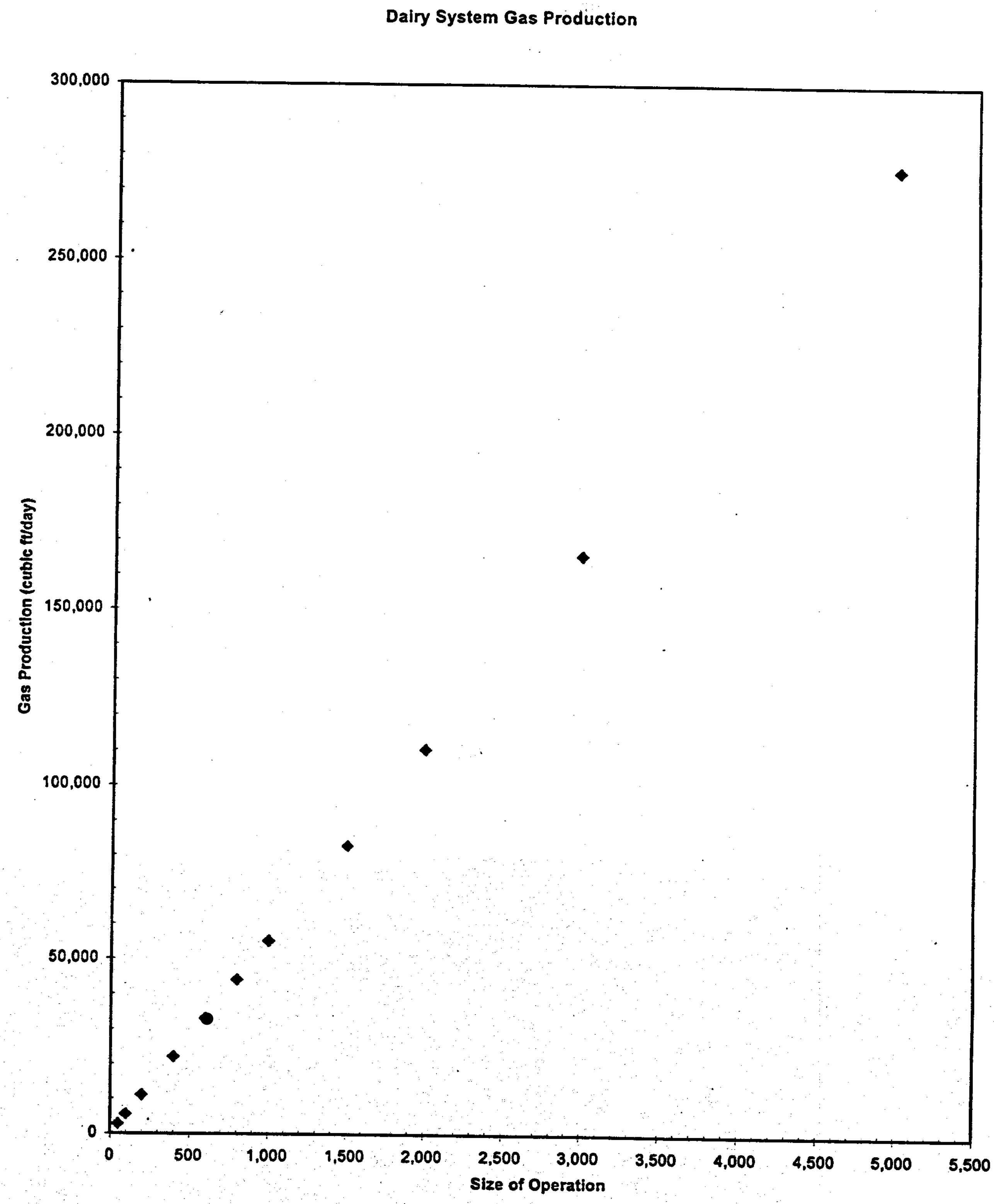


Figure 27: Dairy System Gas Production

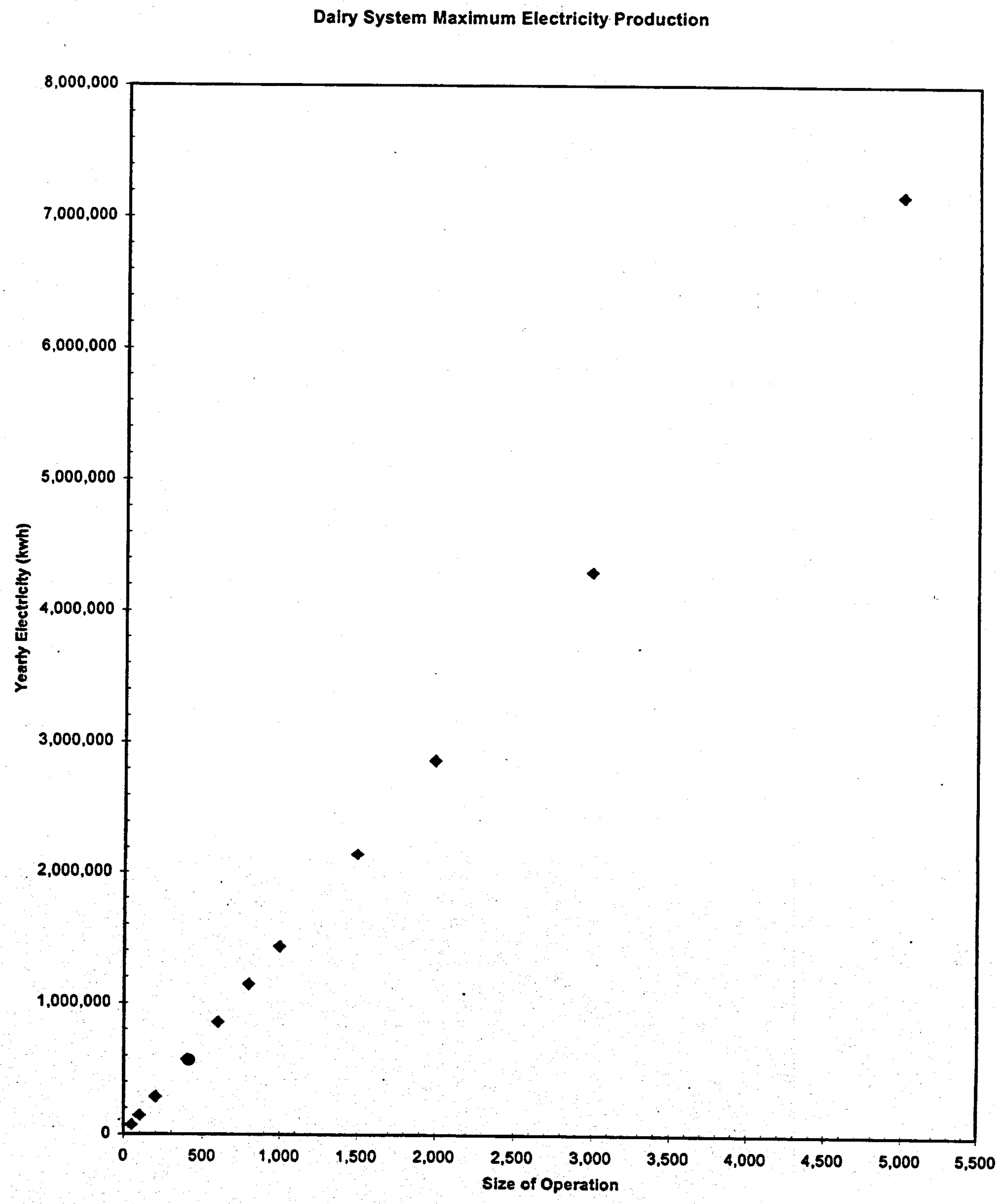


Figure 28: Dairy System Maximum Energy Production

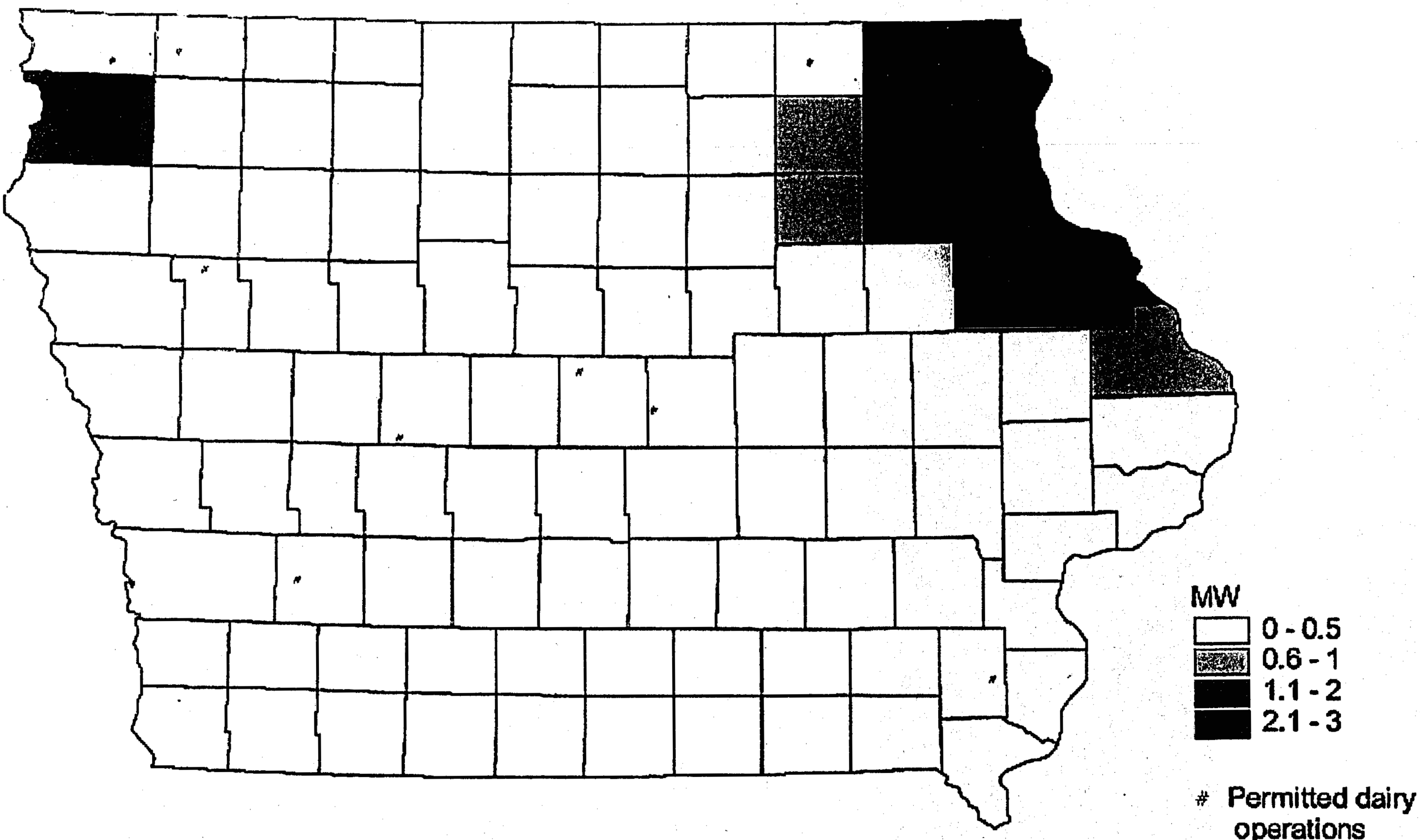


Figure 29: Electricity output (MW) per county if all available dairy manure generated methane is combusted in an engine generator (30% efficiency) to generate electricity.

Figure 30: Electricity output (MW) per county if all available swine manure generated methane is combusted in an engine generator (30% efficiency) to generate electricity.

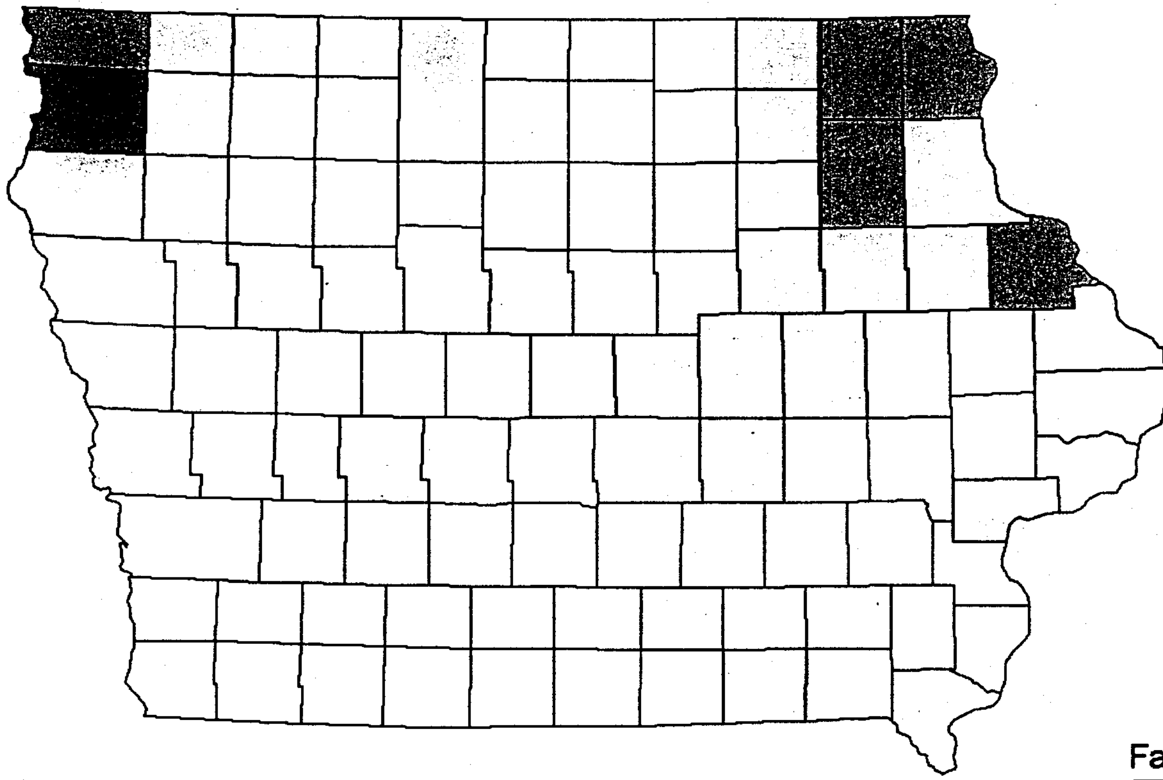
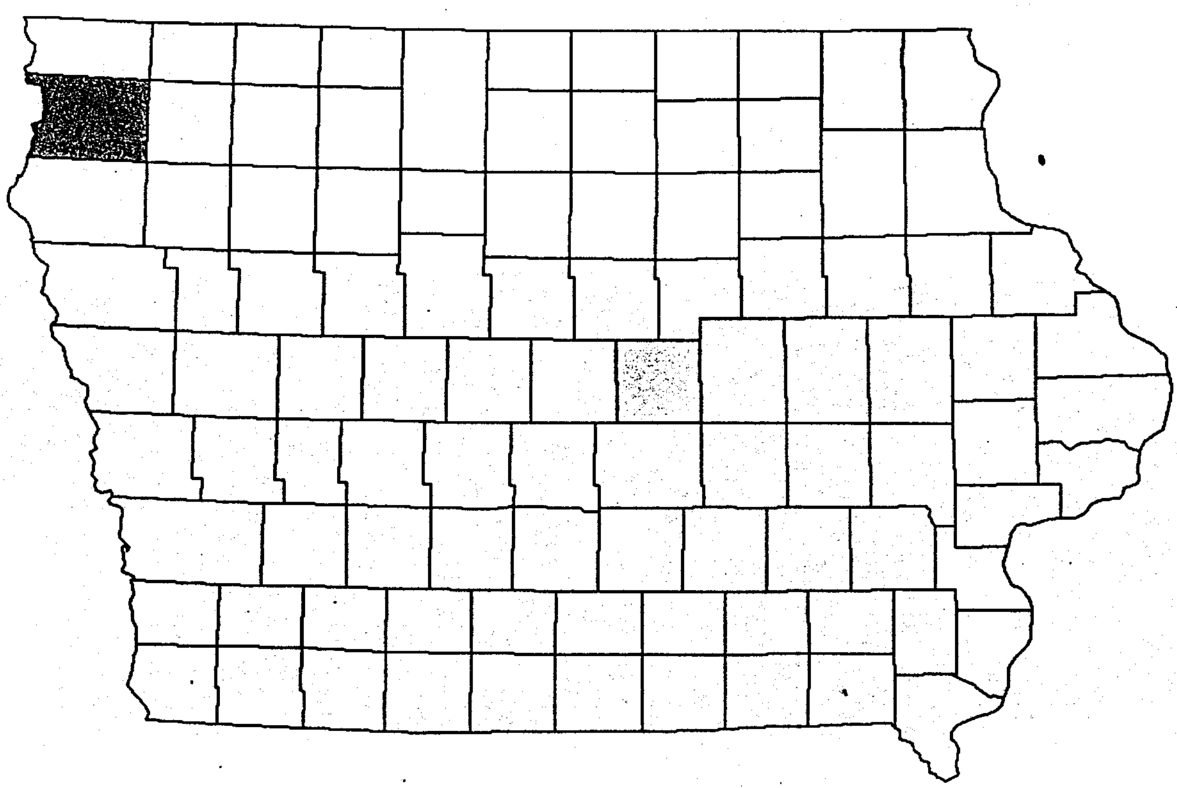


Figure 31: Maximum Number of Farms that Meet Dairy Herd Size Requirements in Table 45 for Scenario #3 (Top) and Scenario #6 (Bottom)



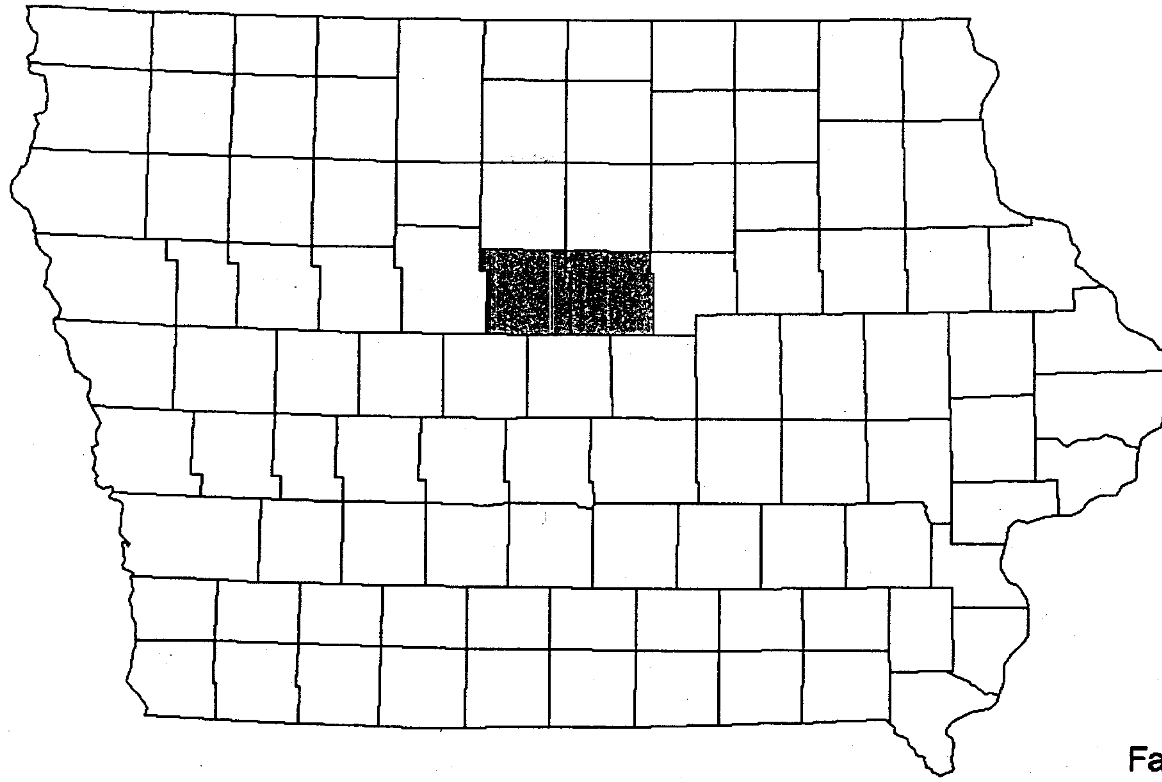
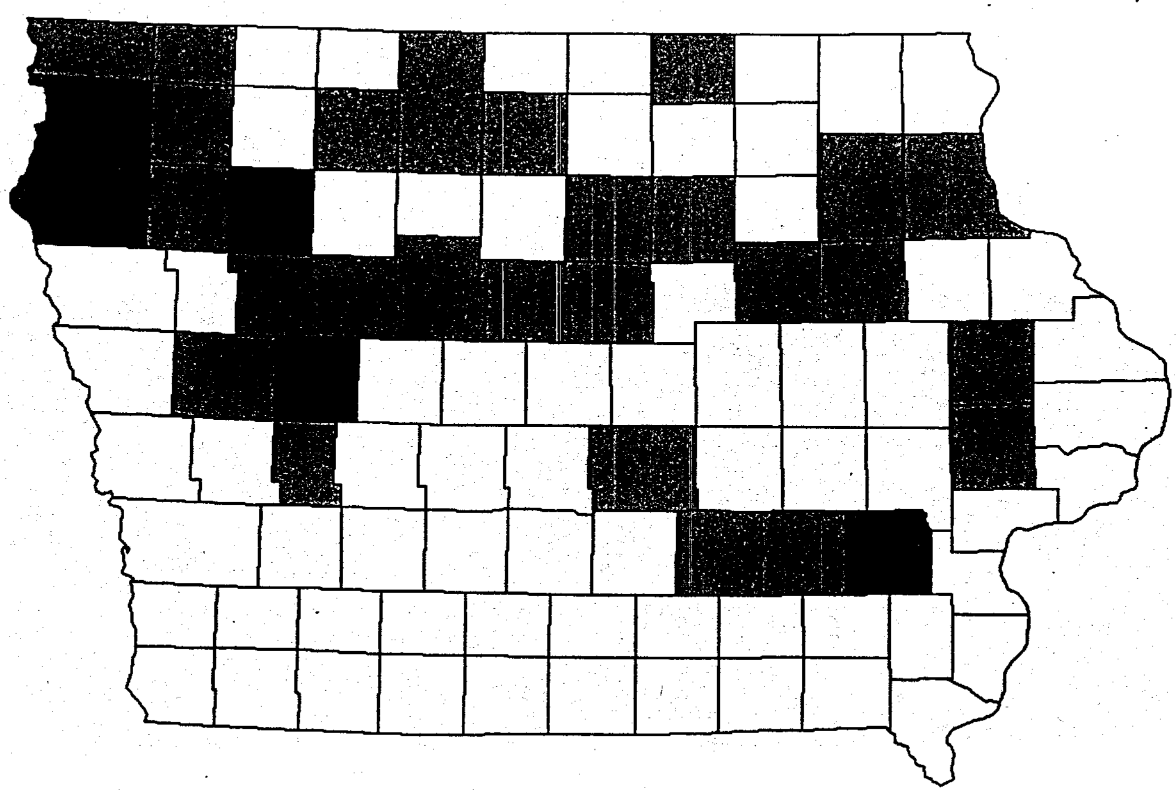


Figure 32: Maximum Number of Farms that Meet Swine Herd Size Requirements in Table 45 for Scenario #3 (Top) and Scenario #6 (Bottom)

Farm Numbers
3 - 38
39 - 96
97 - 219
0



Appendix C

Iowa	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Feedlot Cattle	3,306,618	11,077	3,439,709	2,579,782	14,859,544	43.71
Dairy Cows	222,142	1,555	454,058	408,652	2,402,876	7.07
Swine	14,651,919	10,989	3,208,770	2,567,016	13,348,484	39.27
Poultry Layers	24,876,834	808	217,921	196,129	1,214,431	3.57
Poultry Boilers	1,017,224	22	5,941	5,347	33,106	0.10
Turkeys	2,552,624	217	60,561	36,337	224,996	0.66
Total		24,668	7,386,961	5,793,263	32,083,438	94.38

Characteristic	Feedlot Cattle	Dairy Cattle	Swine	Poultry Layers	Poultry Boilers	Turkeys
Typical Animal Mass (TAM), (lb)	800	1400	170	4	2	15
Total Solids (lb/day)	6.7	14	1.5	0.065	0.043	0.17
Volatile Solids (VS), (lb/day)	5.7	11.2	1.2	0.048	0.032	0.13
Biogas Production (ft^3/lb VS)	9.6	14	8	8.6	8.6	8.6
Biogas Energy Content (Btu/ft^3)	600	600	650	600	600	600
Waste Mg'mt System Handling Loss (%)	25	10	20	10	10	40
Digester Efficiency (%)	50	35	50	60	60	60

FeedLot Cattle

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Adair	52,872	177.1	55,000	41,250	237,600	0.699
Adams	39,426	132.1	41,013	30,760	177,176	0.521
Allamakee	53,772	180.1	55,936	41,952	241,645	0.711
Appanoose	42,573	142.6	44,287	33,215	191,318	0.563
Audubon	32,730	109.6	34,047	25,536	147,085	0.433
Benton	38,370	128.5	39,914	29,936	172,430	0.507
Black Hawk	15,050	50.4	15,656	11,742	67,633	0.199
Boone	17,091	57.3	17,779	13,334	76,805	0.226
Bremer	19,103	64.0	19,872	14,904	85,847	0.253
Buchanan	24,404	81.8	25,386	19,040	109,669	0.323
Buena Vista	22,605	75.7	23,515	17,636	101,584	0.299
Butler	20,058	67.2	20,865	15,649	90,138	0.265
Calhoun	17,057	57.1	17,744	13,308	76,652	0.225
Carroll	73,063	244.8	76,004	57,003	328,336	0.966
Cass	49,351	165.3	51,337	38,503	221,777	0.652
Cedar	28,888	96.8	30,051	22,538	129,819	0.382
Cerro Gordo	8,858	29.7	9,215	6,911	39,807	0.117

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Cherokee	47,783	160.1	49,706	37,280	214,731	0.632
Chickasaw	33,433	112.0	34,779	26,084	150,244	0.442
Clarke	40,364	135.2	41,989	31,491	181,391	0.534
Clay	11,217	37.6	11,668	8,751	50,408	0.148
Clayton	61,395	205.7	63,866	47,900	275,902	0.812
Clinton	51,622	172.9	53,700	40,275	231,983	0.682
Crawford	60,007	201.0	62,422	46,817	269,664	0.793
Dallas	16,123	54.0	16,772	12,579	72,455	0.213
Davis	45,627	152.9	47,463	35,598	205,042	0.603
Decatur	61,391	205.7	63,862	47,896	275,884	0.812
Delaware	51,555	172.7	53,630	40,223	231,682	0.682
Des Moines	14,823	49.7	15,420	11,565	66,613	0.196
Dickinson	26,260	88.0	27,317	20,488	118,009	0.347
Dubuque	84,146	281.9	87,533	65,650	378,142	1.112
Emmet	15,161	50.8	15,771	11,828	68,132	0.200
Fayette	46,490	155.7	48,361	36,271	208,920	0.615
Floyd	14,958	50.1	15,560	11,670	67,219	0.198
Franklin	18,816	63.0	19,573	14,680	84,557	0.249
Fremont	15,843	53.1	16,481	12,361	71,197	0.209
Greene	21,033	70.5	21,880	16,410	94,520	0.278
Grundy	19,098	64.0	19,867	14,900	85,824	0.252
Guthrie	36,439	122.1	37,906	28,429	163,752	0.482
Hamilton	4,810	16.1	5,004	3,753	21,616	0.064
Hancock	11,261	37.7	11,714	8,786	50,606	0.149
Hardin	19,364	64.9	20,143	15,108	87,019	0.256
Harrison	33,609	112.6	34,962	26,221	151,035	0.444
Henry	17,711	59.3	18,424	13,818	79,591	0.234
Howard	26,090	87.4	27,140	20,355	117,245	0.345
Humboldt	11,637	39.0	12,105	9,079	52,295	0.154
Ida	23,638	79.2	24,589	18,442	106,226	0.312
Iowa	43,389	145.4	45,135	33,852	194,985	0.574
Jackson	81,725	273.8	85,014	63,761	367,262	1.080
Jasper	45,159	151.3	46,977	35,232	202,939	0.597
Jefferson	19,756	66.2	20,551	15,413	88,781	0.261
Johnson	35,052	117.4	36,463	27,347	157,519	0.463
Jones	57,783	193.6	60,109	45,082	259,670	0.764
Keokuk	28,398	95.1	29,541	22,156	127,617	0.375
Kossuth	29,240	98.0	30,417	22,813	131,401	0.387
Lee	25,437	85.2	26,461	19,846	114,311	0.336
Linn	34,757	116.4	36,156	27,117	156,194	0.459
Louisa	11,076	37.1	11,522	8,641	49,774	0.146
Lucas	40,267	134.9	41,888	31,416	180,955	0.532
Lyon	74,152	248.4	77,137	57,852	333,230	0.980
Madison	44,683	149.7	46,481	34,861	200,800	0.591
Mahaska	40,315	135.1	41,938	31,453	181,171	0.533
Marion	30,030	100.6	31,239	23,429	134,951	0.397
Marshall	24,558	82.3	25,546	19,160	110,361	0.325
Mills	14,090	47.2	14,657	10,993	63,319	0.186

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Mitchell	41,639	139.5	43,315	32,486	187,121	0.550
Monona	36,207	121.3	37,664	28,248	162,710	0.479
Monroe	36,383	121.9	37,847	28,386	163,501	0.481
Montgomery	29,110	97.5	30,282	22,711	130,817	0.385
Muscatine	18,174	60.9	18,906	14,179	81,672	0.240
O'Brien	33,304	111.6	34,644	25,983	149,664	0.440
Osceola	29,588	99.1	30,779	23,084	132,965	0.391
Page	39,386	131.9	40,971	30,728	176,996	0.521
Palo Alto	18,481	61.9	19,225	14,419	83,051	0.244
Plymouth	76,916	257.7	80,012	60,009	345,651	1.017
Pocahontas	11,214	37.6	11,665	8,749	50,394	0.148
Polk	9,528	31.9	9,912	7,434	42,818	0.126
Pottawattamie	63,490	212.7	66,045	49,534	285,316	0.839
Poweshiek	39,434	132.1	41,021	30,766	177,212	0.521
Ringgold	41,731	139.8	43,411	32,558	187,534	0.552
Sac	38,788	129.9	40,349	30,262	174,309	0.513
Scott	19,639	65.8	20,429	15,322	88,255	0.260
Shelby	40,019	134.1	41,630	31,222	179,841	0.529
Sioux	159,839	535.5	166,273	124,704	718,297	2.113
Story	15,623	52.3	16,252	12,189	70,208	0.207
Tama	32,621	109.3	33,934	25,450	146,595	0.431
Taylor	36,510	122.3	37,980	28,485	164,072	0.483
Union	19,442	65.1	20,225	15,168	87,370	0.257
Van Buren	29,728	99.6	30,925	23,193	133,594	0.393
Wapello	20,536	68.8	21,363	16,022	92,286	0.271
Warren	38,988	130.6	40,557	30,418	175,207	0.515
Washington	24,167	81.0	25,140	18,855	108,604	0.319
Wayne	42,003	140.7	43,694	32,770	188,756	0.555
Webster	12,578	42.1	13,084	9,813	56,524	0.166
Winnebago	5,461	18.3	5,681	4,261	24,541	0.072
Winneshiek	61,741	206.8	64,226	48,170	277,457	0.816
Woodbury	62,525	209.5	65,042	48,781	280,980	0.827
Worth	9,425	31.6	9,804	7,353	42,355	0.125
Wright	5,181	17.4	5,390	4,042	23,283	0.068

Dairy Cattle

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Adair	296	2.1	605	545	3,202	0.009
Adams	177	1.2	362	326	1,915	0.006
Allamakee	15,173	106.2	31,014	27,912	164,124	0.483
Appanoose	398	2.8	814	732	4,305	0.013
Audubon	190	1.3	388	350	2,055	0.006
Benton	2,029	14.2	4,147	3,733	21,947	0.065
Black Hawk	1,491	10.4	3,048	2,743	16,128	0.047
Boone	104	0.7	213	191	1,125	0.003

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Bremer	5,398	37.8	11,034	9,930	58,389	0.172
Buchanan	3,785	26.5	7,737	6,963	40,942	0.120
Buena Vista	321	2.2	656	591	3,472	0.010
Butler	1,827	12.8	3,734	3,361	19,762	0.058
Calhoun	0	0.0	0	0	0	0.000
Carroll	233	1.6	476	429	2,520	0.007
Cass	363	2.5	742	668	3,927	0.012
Cedar	899	6.3	1,838	1,654	9,724	0.029
Cerro Gordo	560	3.9	1,145	1,030	6,057	0.018
Cherokee	804	5.6	1,643	1,479	8,697	0.026
Chickasaw	5,674	39.7	11,598	10,438	61,375	0.181
Clarke	357	2.5	730	657	3,862	0.011
Clay	0	0.0	0	0	0	0.000
Clayton	21,965	153.8	44,896	40,407	237,592	0.699
Clinton	2,482	17.4	5,073	4,566	26,847	0.079
Crawford	668	4.7	1,365	1,229	7,226	0.021
Dallas	98	0.7	200	180	1,060	0.003
Davis	1,834	12.8	3,749	3,374	19,838	0.058
Decatur	232	1.6	474	427	2,510	0.007
Delaware	18,844	131.9	38,517	34,665	203,833	0.600
Des Moines	520	3.6	1,063	957	5,625	0.017
Dickinson	586	4.1	1,198	1,078	6,339	0.019
Dubuque	27,998	196.0	57,228	51,505	302,850	0.891
Emmet	0	0.0	0	0	0	0.000
Fayette	12,778	89.4	26,118	23,506	138,218	0.407
Floyd	963	6.7	1,968	1,772	10,417	0.031
Franklin	436	3.1	891	802	4,716	0.014
Fremont	0	0.0	0	0	0	0.000
Greene	8	0.1	16	15	87	0.000
Grundy	745	5.2	1,523	1,371	8,059	0.024
Guthrie	557	3.9	1,139	1,025	6,025	0.018
Hamilton	340	2.4	695	625	3,678	0.011
Hancock	355	2.5	726	653	3,840	0.011
Hardin	161	1.1	329	296	1,742	0.005
Harrison	84	0.6	172	155	909	0.003
Henry	364	2.5	744	670	3,937	0.012
Howard	4,561	31.9	9,323	8,390	49,336	0.145
Humboldt	299	2.1	611	550	3,234	0.010
Ida	0	0.0	0	0	0	0.000
Iowa	994	7.0	2,032	1,829	10,752	0.032
Jackson	7,592	53.1	15,518	13,966	82,122	0.242
Jasper	857	6.0	1,752	1,577	9,270	0.027
Jefferson	524	3.7	1,071	964	5,668	0.017
Johnson	2,938	20.6	6,005	5,405	31,780	0.093
Jones	3,256	22.8	6,655	5,990	35,220	0.104
Keokuk	203	1.4	415	373	2,196	0.006
Kossuth	1,191	8.3	2,434	2,191	12,883	0.038
Lee	1,447	10.1	2,958	2,662	15,652	0.046

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Linn	2,033	14.2	4,155	3,740	21,991	0.065
Louisa	193	1.4	394	355	2,088	0.006
Lucas	239	1.7	489	440	2,585	0.008
Lyon	4,315	30.2	8,820	7,938	46,675	0.137
Madison	12	0.1	25	22	130	0.000
Mahaska	1,106	7.7	2,261	2,035	11,963	0.035
Marion	742	5.2	1,517	1,365	8,026	0.024
Marshall	855	6.0	1,748	1,573	9,248	0.027
Mills	85	0.6	174	156	919	0.003
Mitchell	2,996	21.0	6,124	5,511	32,407	0.095
Monona	217	1.5	444	399	2,347	0.007
Monroe	705	4.9	1,441	1,297	7,626	0.022
Montgomery	247	1.7	505	454	2,672	0.008
Muscatine	1,043	7.3	2,132	1,919	11,282	0.033
O'Brien	760	5.3	1,553	1,398	8,221	0.024
Osceola	1,338	9.4	2,735	2,461	14,473	0.043
Page	75	0.5	153	138	811	0.002
Palo Alto	362	2.5	740	666	3,916	0.012
Plymouth	2,215	15.5	4,527	4,075	23,959	0.070
Pocahontas	443	3.1	905	815	4,792	0.014
Polk	246	1.7	503	453	2,661	0.008
Pottawattamie	314	2.2	642	578	3,396	0.010
Poweshiek	1,091	7.6	2,230	2,007	11,801	0.035
Ringgold	242	1.7	495	445	2,618	0.008
Sac	754	5.3	1,541	1,387	8,156	0.024
Scott	844	5.9	1,725	1,553	9,129	0.027
Shelby	324	2.3	662	596	3,505	0.010
Sioux	14,214	99.5	29,053	26,148	153,751	0.452
Story	1,342	9.4	2,743	2,469	14,516	0.043
Tama	1,460	10.2	2,984	2,686	15,793	0.046
Taylor	220	1.5	450	405	2,380	0.007
Union	0	0.0	0	0	0	0.000
Van Buren	941	6.6	1,923	1,731	10,179	0.030
Wapello	439	3.1	897	808	4,749	0.014
Warren	494	3.5	1,010	909	5,344	0.016
Washington	1,272	8.9	2,600	2,340	13,759	0.040
Wayne	479	3.4	979	881	5,181	0.015
Webster	292	2.0	597	537	3,159	0.009
Winnebago	533	3.7	1,089	981	5,765	0.017
Winneshiek	19,617	137.3	40,097	36,087	212,194	0.624
Woodbury	109	0.8	223	201	1,179	0.003
Worth	467	3.3	955	859	5,051	0.015
Wright	64	0.4	131	118	692	0.002

Swine						
County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Adair	39,032	29.3	8,548	6,838	35,560	0.105
Adams	58,998	44.2	12,921	10,336	53,750	0.158
Allamakee	72,111	54.1	15,792	12,634	65,696	0.193
Appanoose	5,462	4.1	1,196	957	4,976	0.015
Audubon	168,217	126.2	36,840	29,472	153,252	0.451
Benton	102,216	76.7	22,385	17,908	93,123	0.274
Black Hawk	171,797	128.8	37,624	30,099	156,514	0.460
Boone	101,679	76.3	22,268	17,814	92,634	0.273
Bremer	88,693	66.5	19,424	15,539	80,803	0.238
Buchanan	191,642	143.7	41,970	33,576	174,594	0.514
Buena Vista	298,220	223.7	65,310	52,248	271,690	0.799
Butler	178,682	134.0	39,131	31,305	162,786	0.479
Calhoun	171,427	128.6	37,543	30,034	156,177	0.459
Carroll	372,598	279.4	81,599	65,279	339,452	0.999
Cass	64,720	48.5	14,174	11,339	58,963	0.173
Cedar	151,936	114.0	33,274	26,619	138,420	0.407
Cerro Gordo	126,766	95.1	27,762	22,209	115,489	0.340
Cherokee	222,808	167.1	48,795	39,036	202,987	0.597
Chickasaw	131,490	98.6	28,796	23,037	119,793	0.352
Clarke	67,224	50.4	14,722	11,778	61,244	0.180
Clay	108,489	81.4	23,759	19,007	98,838	0.291
Clayton	242,580	181.9	53,125	42,500	221,000	0.650
Clinton	101,869	76.4	22,309	17,847	92,807	0.273
Crawford	179,383	134.5	39,285	31,428	163,425	0.481
Dallas	56,587	42.4	12,393	9,914	51,553	0.152
Davis	123,102	92.3	26,959	21,567	112,151	0.330
Decatur	39,037	29.3	8,549	6,839	35,564	0.105
Delaware	401,729	301.3	87,979	70,383	365,991	1.077
Des Moines	125,030	93.8	27,382	21,905	113,907	0.335
Dickinson	45,333	34.0	9,928	7,942	41,300	0.121
Dubuque	258,568	193.9	56,626	45,301	235,566	0.693
Emmet	120,605	90.5	26,412	21,130	109,876	0.323
Fayette	242,628	182.0	53,136	42,508	221,044	0.650
Floyd	106,157	79.6	23,248	18,599	96,713	0.285
Franklin	198,056	148.5	43,374	34,699	180,437	0.531
Fremont	24,261	18.2	5,313	4,251	22,103	0.065
Greene	154,717	116.0	33,883	27,106	140,953	0.415
Grundy	156,834	117.6	34,347	27,477	142,882	0.420
Guthrie	81,536	61.2	17,856	14,285	74,283	0.219
Hamilton	448,312	336.2	98,180	78,544	408,430	1.201
Hancock	174,621	131.0	38,242	30,594	159,087	0.468
Hardin	395,359	296.5	86,584	69,267	360,188	1.060
Harrison	66,383	49.8	14,538	11,630	60,478	0.178
Henry	88,271	66.2	19,331	15,465	80,418	0.237
Howard	98,979	74.2	21,676	17,341	90,174	0.265
Humboldt	85,721	64.3	18,773	15,018	78,095	0.230
Ida	120,684	90.5	26,430	21,144	109,948	0.323

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Iowa	134,113	100.6	29,371	23,497	122,182	0.359
Jackson	89,234	66.9	19,542	15,634	81,296	0.239
Jasper	180,743	135.6	39,583	31,666	164,664	0.484
Jefferson	72,998	54.7	15,987	12,789	66,504	0.196
Johnson	137,946	103.5	30,210	24,168	125,674	0.370
Jones	147,204	110.4	32,238	25,790	134,109	0.395
Keokuk	144,412	108.3	31,626	25,301	131,565	0.387
Kossuth	323,029	242.3	70,743	56,595	294,292	0.866
Lee	113,345	85.0	24,823	19,858	103,262	0.304
Linn	80,301	60.2	17,586	14,069	73,157	0.215
Louisa	90,189	67.6	19,751	15,801	82,166	0.242
Lucas	19,082	14.3	4,179	3,343	17,384	0.051
Lyon	325,619	244.2	71,311	57,048	296,652	0.873
Madison	40,136	30.1	8,790	7,032	36,566	0.108
Mahaska	247,819	185.9	54,272	43,418	225,773	0.664
Marion	80,740	60.6	17,682	14,146	73,557	0.216
Marshall	118,159	88.6	25,877	20,701	107,648	0.317
Mills	17,544	13.2	3,842	3,074	15,983	0.047
Mitchell	265,686	199.3	58,185	46,548	242,051	0.712
Monona	55,490	41.6	12,152	9,722	50,554	0.149
Monroe	45,184	33.9	9,895	7,916	41,164	0.121
Montgomery	38,330	28.7	8,394	6,715	34,920	0.103
Muscatine	68,777	51.6	15,062	12,050	62,659	0.184
O'Brien	283,000	212.3	61,977	49,582	257,824	0.758
Osceola	216,701	162.5	47,458	37,966	197,423	0.581
Page	61,151	45.9	13,392	10,714	55,711	0.164
Palo Alto	199,116	149.3	43,606	34,885	181,403	0.534
Plymouth	460,965	345.7	100,951	80,761	419,958	1.235
Pocahontas	118,209	88.7	25,888	20,710	107,693	0.317
Polk	21,780	16.3	4,770	3,816	19,842	0.058
Pottawattamie	87,323	65.5	19,124	15,299	79,555	0.234
Poweshiek	109,074	81.8	23,887	19,110	99,371	0.292
Ringgold	181,241	135.9	39,692	31,753	165,118	0.486
Sac	350,473	262.9	76,754	61,403	319,295	0.939
Scott	104,705	78.5	22,930	18,344	95,390	0.281
Shelby	119,133	89.3	26,090	20,872	108,535	0.319
Sioux	762,294	571.7	166,942	133,554	694,480	2.043
Story	102,688	77.0	22,489	17,991	93,553	0.275
Tama	103,275	77.5	22,617	18,094	94,088	0.277
Taylor	41,037	30.8	8,987	7,190	37,386	0.110
Union	56,082	42.1	12,282	9,826	51,093	0.150
Van Buren	43,971	33.0	9,630	7,704	40,059	0.118
Wapello	34,941	26.2	7,652	6,122	31,833	0.094
Warren	42,339	31.8	9,272	7,418	38,573	0.113
Washington	436,353	327.3	95,561	76,449	397,535	1.169
Wayne	20,808	15.6	4,557	3,646	18,957	0.056
Webster	149,935	112.5	32,836	26,269	136,597	0.402
Winnebago	44,371	33.3	9,717	7,774	40,424	0.119

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Winneshiek	125,534	94.2	27,492	21,994	114,366	0.336
Woodbury	103,850	77.9	22,743	18,195	94,612	0.278
Worth	46,325	34.7	10,145	8,116	42,204	0.124
Wright	358,616	269.0	78,537	62,830	326,714	0.961

Poultry Layers

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Adair	0	0.0	0	0	0.0	0.000
Adams	2,057	0.1	18	16	100.4	0.000
Allamakee	413	0.0	4	3	20.2	0.000
Appanoose	410	0.0	4	3	20.0	0.000
Audubon	0	0.0	0	0	0.0	0.000
Benton	0	0.0	0	0	0.0	0.000
Black Hawk	0	0.0	0	0	0.0	0.000
Boone	0	0.0	0	0	0.0	0.000
Bremer	0	0.0	0	0	0.0	0.000
Buchanan	0	0.0	0	0	0.0	0.000
Buena Vista	0	0.0	0	0	0.0	0.000
Butler	0	0.0	0	0	0.0	0.000
Calhoun	340	0.0	3	3	16.6	0.000
Carroll	600	0.0	5	5	29.3	0.000
Cass	0	0.0	0	0	0.0	0.000
Cedar	405	0.0	4	3	19.8	0.000
Cerro Gordo	35,664	1.2	312	281	1,741.0	0.005
Cherokee	0	0.0	0	0	0.0	0.000
Chickasaw	782	0.0	7	6	38.2	0.000
Clarke	1,146	0.0	10	9	55.9	0.000
Clay	0	0.0	0	0	0.0	0.000
Clayton	449,504	14.6	3,938	3,544	21,943.8	0.065
Clinton	991	0.0	9	8	48.4	0.000
Crawford	0	0.0	0	0	0.0	0.000
Dallas	213,237	6.9	1,868	1,681	10,409.7	0.031
Davis	11,442	0.4	100	90	558.6	0.002
Decatur	375	0.0	3	3	18.3	0.000
Delaware	0	0.0	0	0	0.0	0.000
Des Moines	309	0.0	3	2	15.1	0.000
Dickinson	84	0.0	1	1	4.1	0.000
Dubuque	1,337	0.0	12	11	65.3	0.000
Emmet	0	0.0	0	0	0.0	0.000
Fayette	0	0.0	0	0	0.0	0.000
Floyd	0	0.0	0	0	0.0	0.000
Franklin	0	0.0	0	0	0.0	0.000
Fremont	123	0.0	1	1	6.0	0.000
Greene	908	0.0	8	7	44.3	0.000
Grundy	163,891	5.3	1,436	1,292	8,000.8	0.024

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Guthrie	0	0.0	0	0	0.0	0.000
Hamilton	12,356	0.4	108	97	603.2	0.002
Hancock	0	0.0	0	0	0.0	0.000
Hardin	0	0.0	0	0	0.0	0.000
Harrison	596	0.0	5	5	29.1	0.000
Henry	312	0.0	3	2	15.2	0.000
Howard	1,382	0.0	12	11	67.5	0.000
Humboldt	133,062	4.3	1,166	1,049	6,495.8	0.019
Ida	1,201	0.0	11	9	58.6	0.000
Iowa	813	0.0	7	6	39.7	0.000
Jackson	0	0.0	0	0	0.0	0.000
Jasper	0	0.0	0	0	0.0	0.000
Jefferson	780	0.0	7	6	38.1	0.000
Johnson	64,027	2.1	561	505	3,125.7	0.009
Jones	364	0.0	3	3	17.8	0.000
Keokuk	0	0.0	0	0	0.0	0.000
Kossuth	9,515	0.3	83	75	464.5	0.001
Lee	1,428	0.0	13	11	69.7	0.000
Linn	1,363	0.0	12	11	66.5	0.000
Louisa	94	0.0	1	1	4.6	0.000
Lucas	432	0.0	4	3	21.1	0.000
Lyon	0	0.0	0	0	0.0	0.000
Madison	0	0.0	0	0	0.0	0.000
Mahaska	0	0.0	0	0	0.0	0.000
Marion	769	0.0	7	6	37.5	0.000
Marshall	0	0.0	0	0	0.0	0.000
Mills	260	0.0	2	2	12.7	0.000
Mitchell	279,987	9.1	2,453	2,207	13,668.3	0.040
Monona	193	0.0	2	2	9.4	0.000
Monroe	153	0.0	1	1	7.5	0.000
Montgomery	0	0.0	0	0	0.0	0.000
Muscatine	1,886	0.1	17	15	92.1	0.000
O'Brien	304,897	9.9	2,671	2,404	14,884.4	0.044
Osceola	0	0.0	0	0	0.0	0.000
Page	841	0.0	7	7	41.1	0.000
Palo Alto	817,505	26.6	7,161	6,445	39,908.7	0.117
Plymouth	7,763	0.3	68	61	379.0	0.001
Pocahontas	0	0.0	0	0	0.0	0.000
Polk	263	0.0	2	2	12.8	0.000
Pottawattamie	907	0.0	8	7	44.3	0.000
Poweshiek	0	0.0	0	0	0.0	0.000
Ringgold	303	0.0	3	2	14.8	0.000
Sac	96,168	3.1	842	758	4,694.7	0.014
Scott	2,064	0.1	18	16	100.8	0.000
Shelby	582	0.0	5	5	28.4	0.000
Sioux	1,573,881	51.2	13,787	12,408	76,833.3	0.226
Story	1,132	0.0	10	9	55.3	0.000
Tama	1,107	0.0	10	9	54.0	0.000

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Taylor	0	0.0	0	0	0.0	0.000
Union	148	0.0	1	1	7.2	0.000
Van Buren	975	0.0	9	8	47.6	0.000
Wapello	526	0.0	5	4	25.7	0.000
Warren	620	0.0	5	5	30.3	0.000
Washington	399,737	13.0	3,502	3,152	19,514.3	0.057
Wayne	230	0.0	2	2	11.2	0.000
Webster	0	0.0	0	0	0.0	0.000
Winnebago	619	0.0	5	5	30.2	0.000
Winneshiek	0	0.0	0	0	0.0	0.000
Woodbury	1,267	0.0	11	10	61.9	0.000
Worth	0	0.0	0	0	0.0	0.000
Wright	0	0.0	0	0	0.0	0.000

Poultry Boilers

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Adair	285	0.0	2	1	9.3	0.000
Adams	0	0.0	0	0	0.0	0.000
Allamakee	0	0.0	0	0	0.0	0.000
Appanoose	533	0.0	3	3	17.3	0.000
Audubon	124	0.0	1	1	4.0	0.000
Benton	586	0.0	3	3	19.1	0.000
Black Hawk	218	0.0	1	1	7.1	0.000
Boone	508	0.0	3	3	16.5	0.000
Bremer	1,435	0.0	8	8	46.7	0.000
Buchanan	39,013	0.8	228	205	1,269.7	0.004
Buena Vista	853	0.0	5	4	27.8	0.000
Butler	0	0.0	0	0	0.0	0.000
Calhoun	3,048	0.1	18	16	99.2	0.000
Carroll	266	0.0	2	1	8.7	0.000
Cass	0	0.0	0	0	0.0	0.000
Cedar	426	0.0	2	2	13.9	0.000
Cerro Gordo	40	0.0	0	0	1.3	0.000
Cherokee	0	0.0	0	0	0.0	0.000
Chickasaw	420	0.0	2	2	13.7	0.000
Clarke	0	0.0	0	0	0.0	0.000
Clay	381	0.0	2	2	12.4	0.000
Clayton	219	0.0	1	1	7.1	0.000
Clinton	570	0.0	3	3	18.6	0.000
Crawford	765	0.0	4	4	24.9	0.000
Dallas	260	0.0	2	1	8.5	0.000
Davis	413	0.0	2	2	13.4	0.000
Decatur	809	0.0	5	4	26.3	0.000
Delaware	258	0.0	2	1	8.4	0.000
Des Moines	245	0.0	1	1	8.0	0.000

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Dickinson	0	0.0	0	0	0.0	0.000
Dubuque	713	0.0	4	4	23.2	0.000
Emmet	0	0.0	0	0	0.0	0.000
Fayette	339	0.0	2	2	11.0	0.000
Floyd	485	0.0	3	3	15.8	0.000
Franklin	770	0.0	4	4	25.1	0.000
Fremont	0	0.0	0	0	0.0	0.000
Greene	2,709	0.1	16	14	88.2	0.000
Grundy	1,500	0.0	9	8	48.8	0.000
Guthrie	602	0.0	4	3	19.6	0.000
Hamilton	229	0.0	1	1	7.5	0.000
Hancock	460	0.0	3	2	15.0	0.000
Hardin	315	0.0	2	2	10.3	0.000
Harrison	435	0.0	3	2	14.2	0.000
Henry	350	0.0	2	2	11.4	0.000
Howard	764	0.0	4	4	24.9	0.000
Humboldt	0	0.0	0	0	0.0	0.000
Ida	1,495	0.0	9	8	48.7	0.000
Iowa	1,254	0.0	7	7	40.8	0.000
Jackson	597	0.0	3	3	19.4	0.000
Jasper	234	0.0	1	1	7.6	0.000
Jefferson	162	0.0	1	1	5.3	0.000
Johnson	4,023	0.1	23	21	130.9	0.000
Jones	338	0.0	2	2	11.0	0.000
Keokuk	900	0.0	5	5	29.3	0.000
Kossuth	2,135	0.0	12	11	69.5	0.000
Lee	72	0.0	0	0	2.3	0.000
Linn	328	0.0	2	2	10.7	0.000
Louisa	0	0.0	0	0	0.0	0.000
Lucas	1,020	0.0	6	5	33.2	0.000
Lyon	0	0.0	0	0	0.0	0.000
Madison	606	0.0	4	3	19.7	0.000
Mahaska	0	0.0	0	0	0.0	0.000
Marion	0	0.0	0	0	0.0	0.000
Marshall	400	0.0	2	2	13.0	0.000
Mills	175	0.0	1	1	5.7	0.000
Mitchell	903	0.0	5	5	29.4	0.000
Monona	450	0.0	3	2	14.6	0.000
Monroe	0	0.0	0	0	0.0	0.000
Montgomery	200	0.0	1	1	6.5	0.000
Muscatine	490	0.0	3	3	15.9	0.000
O'Brien	175	0.0	1	1	5.7	0.000
Osceola	0	0.0	0	0	0.0	0.000
Page	0	0.0	0	0	0.0	0.000
Palo Alto	1,220	0.0	7	6	39.7	0.000
Plymouth	199	0.0	1	1	6.5	0.000
Pocahontas	0	0.0	0	0	0.0	0.000
Polk	615	0.0	4	3	20.0	0.000

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Pottawattamie	1,184	0.0	7	6	38.5	0.000
Poweshiek	252	0.0	1	1	8.2	0.000
Ringgold	0	0.0	0	0	0.0	0.000
Sac	517	0.0	3	3	16.8	0.000
Scott	0	0.0	0	0	0.0	0.000
Shelby	679	0.0	4	4	22.1	0.000
Sioux	221,062	4.8	1,291	1,162	7,194.5	0.021
Story	894	0.0	5	5	29.1	0.000
Tama	925	0.0	5	5	30.1	0.000
Taylor	0	0.0	0	0	0.0	0.000
Union	0	0.0	0	0	0.0	0.000
Van Buren	312	0.0	2	2	10.2	0.000
Wapello	0	0.0	0	0	0.0	0.000
Warren	525	0.0	3	3	17.1	0.000
Washington	0	0.0	0	0	0.0	0.000
Wayne	0	0.0	0	0	0.0	0.000
Webster	0	0.0	0	0	0.0	0.000
Winnebago	122	0.0	1	1	4.0	0.000
Winneshiek	688	0.0	4	4	22.4	0.000
Woodbury	439	0.0	3	2	14.3	0.000
Worth	324	0.0	2	2	10.5	0.000
Wright	276	0.0	2	1	9.0	0.000

Poultry-Turkeys

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Adair	0	0.0	0	0	0.0	0.000
Adams	0	0.0	0	0	0.0	0.000
Allamakee	0	0.0	0	0	0.0	0.000
Appanoose	0	0.0	0	0	0.0	0.000
Audubon	0	0.0	0	0	0.0	0.000
Benton	33	0.0	1	0	2.9	0.000
Black Hawk	0	0.0	0	0	0.0	0.000
Boone	0	0.0	0	0	0.0	0.000
Bremer	0	0.0	0	0	0.0	0.000
Buchanan	0	0.0	0	0	0.0	0.000
Buena Vista	652,179	55.4	15,473	9,284	57,485.1	0.169
Butler	0	0.0	0	0	0.0	0.000
Calhoun	0	0.0	0	0	0.0	0.000
Carroll	10	0.0	0	0	0.9	0.000
Cass	0	0.0	0	0	0.0	0.000
Cedar	0	0.0	0	0	0.0	0.000
Cerro Gordo	8	0.0	0	0	0.7	0.000
Cherokee	0	0.0	0	0	0.0	0.000
Chickasaw	0	0.0	0	0	0.0	0.000
Clarke	0	0.0	0	0	0.0	0.000

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Clay	0	0.0	0	0	0.0	0.000
Clayton	0	0.0	0	0	0.0	0.000
Clinton	161	0.0	4	2	14.2	0.000
Crawford	25	0.0	1	0	2.2	0.000
Dallas	0	0.0	0	0	0.0	0.000
Davis	18	0.0	0	0	1.6	0.000
Decatur	24	0.0	1	0	2.1	0.000
Delaware	22	0.0	1	0	1.9	0.000
Des Moines	0	0.0	0	0	0.0	0.000
Dickinson	0	0.0	0	0	0.0	0.000
Dubuque	30	0.0	1	0	2.6	0.000
Emmet	0	0.0	0	0	0.0	0.000
Fayette	0	0.0	0	0	0.0	0.000
Floyd	0	0.0	0	0	0.0	0.000
Franklin	33	0.0	1	0	2.9	0.000
Fremont	0	0.0	0	0	0.0	0.000
Greene	19	0.0	0	0	1.7	0.000
Grundy	0	0.0	0	0	0.0	0.000
Guthrie	0	0.0	0	0	0.0	0.000
Hamilton	655,000	55.7	15,540	9,324	57,733.7	0.170
Hancock	55	0.0	1	1	4.8	0.000
Hardin	0	0.0	0	0	0.0	0.000
Harrison	0	0.0	0	0	0.0	0.000
Henry	128,362	10.9	3,045	1,827	11,314.2	0.033
Howard	9	0.0	0	0	0.8	0.000
Humboldt	0	0.0	0	0	0.0	0.000
Ida	0	0.0	0	0	0.0	0.000
Iowa	0	0.0	0	0	0.0	0.000
Jackson	177	0.0	4	3	15.6	0.000
Jasper	0	0.0	0	0	0.0	0.000
Jefferson	0	0.0	0	0	0.0	0.000
Johnson	35,214	3.0	835	501	3,103.9	0.009
Jones	32	0.0	1	0	2.8	0.000
Keokuk	0	0.0	0	0	0.0	0.000
Kossuth	75	0.0	2	1	6.6	0.000
Lee	0	0.0	0	0	0.0	0.000
Linn	116	0.0	3	2	10.2	0.000
Louisa	0	0.0	0	0	0.0	0.000
Lucas	0	0.0	0	0	0.0	0.000
Lyon	35	0.0	1	0	3.1	0.000
Madison	72	0.0	2	1	6.3	0.000
Mahaska	0	0.0	0	0	0.0	0.000
Marion	0	0.0	0	0	0.0	0.000
Marshall	0	0.0	0	0	0.0	0.000
Mills	0	0.0	0	0	0.0	0.000
Mitchell	0	0.0	0	0	0.0	0.000
Monona	41	0.0	1	1	3.6	0.000
Monroe	0	0.0	0	0	0.0	0.000

County	Animal Numbers	Total Solids (tons/day)	Volatile Solids (tons/yr)	Collectable Solids (tons/yr)	Potential Energy (MMBtu/yr)	Potential Energy (MW)
Montgomery	0	0.0	0	0	0.0	0.000
Muscatine	0	0.0	0	0	0.0	0.000
O'Brien	0	0.0	0	0	0.0	0.000
Osceola	0	0.0	0	0	0.0	0.000
Page	0	0.0	0	0	0.0	0.000
Palo Alto	0	0.0	0	0	0.0	0.000
Plymouth	41	0.0	1	1	3.6	0.000
Pocahontas	0	0.0	0	0	0.0	0.000
Polk	47	0.0	1	1	4.1	0.000
Pottawattamie	31	0.0	1	0	2.7	0.000
Poweshiek	6	0.0	0	0	0.5	0.000
Ringgold	7	0.0	0	0	0.6	0.000
Sac	0	0.0	0	0	0.0	0.000
Scott	0	0.0	0	0	0.0	0.000
Shelby	0	0.0	0	0	0.0	0.000
Sioux	6	0.0	0	0	0.5	0.000
Story	0	0.0	0	0	0.0	0.000
Tama	34	0.0	1	0	3.0	0.000
Taylor	0	0.0	0	0	0.0	0.000
Union	117	0.0	3	2	10.3	0.000
Van Buren	0	0.0	0	0	0.0	0.000
Wapello	0	0.0	0	0	0.0	0.000
Warren	45	0.0	1	1	4.0	0.000
Washington	325,130	27.6	7,714	4,628	28,658.0	0.084
Wayne	10	0.0	0	0	0.9	0.000
Webster	0	0.0	0	0	0.0	0.000
Winnebago	0	0.0	0	0	0.0	0.000
Winneshiek	14	0.0	0	0	1.2	0.000
Woodbury	0	0.0	0	0	0.0	0.000
Worth	0	0.0	0	0	0.0	0.000
Wright	0	0.0	0	0	0.0	0.000