# BIODIGESTER DEVELOPMENT IN SASKATCHEWAN: AN INSTITUTIONAL ANALYSIS

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# Biodigester Development in Saskatchewan: an Institutional Analysis

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# Abstract

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Biodigesters are a technology that has been applied in equatorial and temperate regions of the world for manure management and energy production. A positive externality is created from the use of biodigesters when volatile gasses that would otherwise enter the atmosphere as greenhouse gasses are captured. The capture of greenhouse gasses suggests that biodigesters are a potential technology for earning greenhouse gas credits given the existence of a carbon credit trading market involving the exchange of emission permits analogous to that of any other commodity.

Complexity and expense of adapting biodigesters for the Saskatchewan climate makes financing or use of such developments problematic. This thesis uses new institutional economics to determine the least transaction cost governance form to encourage investment in biodigesters. What distinguishes this thesis from previous transaction cost economics analysis is that biodigesters involve more than one transaction occurring simultaneously. Despite a thorough review of the economics literature, no other examples involving multiple transactions was found.

The research conducted in this thesis suggests that no one form of governance is superior in mitigating all possible incentives for opportunism in this case. Parties to an

agreement must evaluate which potential costs are worth bearing to encourage investments in biodigesters in Saskatchewan.

This research does however indicate that the organizational form offers the fewest incentives for opportunistic behavior is one in which the Hog Barn and a biodigester are owned as a joint venture between a hog barn management firm and the electricity generator.

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# Table of Contents

# List of Tables

# List of Figures

# List of Graphs

# Chapter 1: Introduction

## 1.0 Background

For more than two decades members of the scientific community have been voicing concerns regarding the impact of human activity on climate change (Leskiw, 1997). During the 1980s, climate change, specifically global warming, became a topic of widespread domestic and international concern. Given the trans-boundary nature of the issue and potential solutions, governments entered into multilateral discussions on a wider range of climate related issues. One set of negotiations was undertaken to formulate policy initiatives whereby governments around the world would agree to reduce anthropomorphic[1] emissions. Efforts by the international community culminated in the 1992 Earth Summit in Rio where 36 countries, including Canada, committed to a voluntary agreement to reduce greenhouse gas emissions (GHG) to 1990 levels by 2000.

Greenhouse gasses absorb and re-emit heat within the atmosphere. The most commonly cited greenhouse gasses are carbon dioxide ($CO_2$), methane ($CH_4$) and

[1] Anthropomorphic greenhouse gas emissions are those that originate from human activities such as the burning of fossil fuels.

nitrous oxide ($N_2O$). Although the parties to this agreement may have been well intentioned, the majority of the 36 signatories did not reduce their emissions over the specified time period. Rather, from 1990 to 1995, GHG emissions for most countries increased (Leskiw, 1997).

In 1995, the Intergovernmental Panel on Climate Change (IPCC) concluded that there is a discernable human influence on global climate and that this influence represents an important stress on the global ecosystem (IPCC, 1995). Concern over this assertion and the apparent difficulties countries have in finding the political will to enforce GHG reductions led to the December 1997 United Nations Framework Convention on Climate Change (FCCC) meeting in Kyoto, Japan. This convention resulted in the drafting of the Kyoto Protocol as a showcase for how, despite past failings, governments could affect GHG output. Canada committed to a six percent reduction of GHGs from 1990 levels by 2012. Since Canadian emissions have been steadily increasing since 1990, a six percent reduction from 1990 requires drastic policy changes to reduce emissions by an estimated 25% from the business as usual scenario (Edwards, 1999).

The Bush government's refusal, in 2001, to ratify The Kyoto Protocol has cast doubt on how, or if, the Canadian government intends to realize GHG reductions. Nevertheless, it is accepted that if policies were enacted for Canada to meet its reduction commitments, it would have profound implications for energy intensive industries such as electrical utilities. A breakdown of emissions by sector is presented in Figure 1.1.

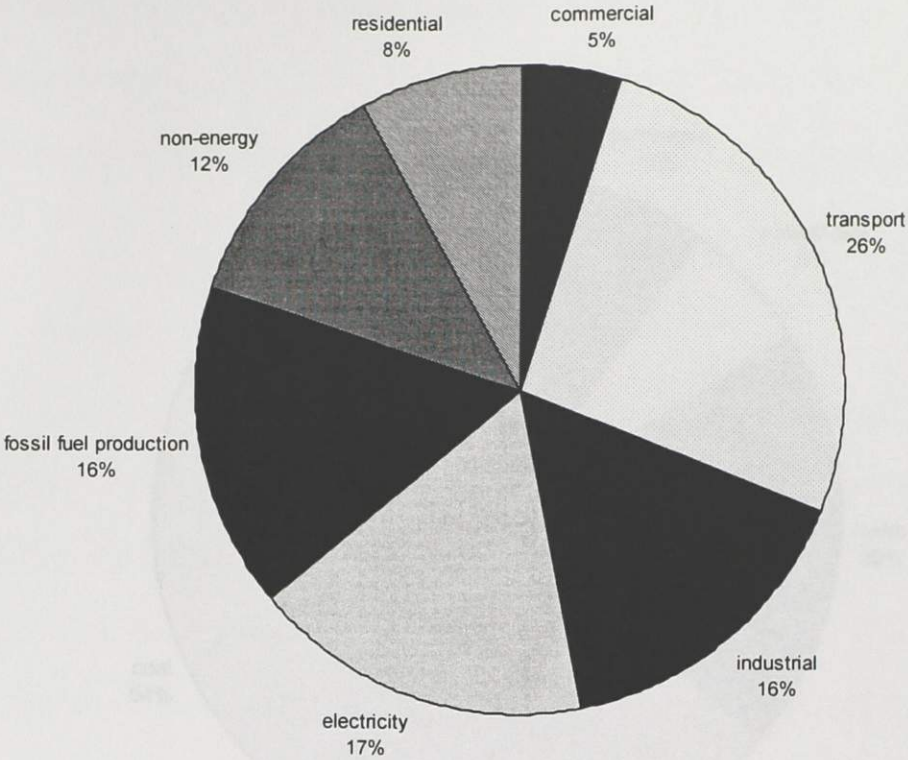



**Figure 1.1 Canada's GHG Emissions by Sector, 1995**
Source: adapted from Natural Resources Canada (1997)

The status of the Federal government's intentions regarding its Kyoto commitments has generated uncertainty for SaskPower, the crown corporation with the responsibility for generating electricity in the province of Saskatchewan, since the thermal generation of electricity is a major contributor of GHGs. Sixty four percent of the electricity generated in Saskatchewan is from coal fired thermo-electric facilities. The sources of electric power in Saskatchewan are indicated in Figure 1.2.

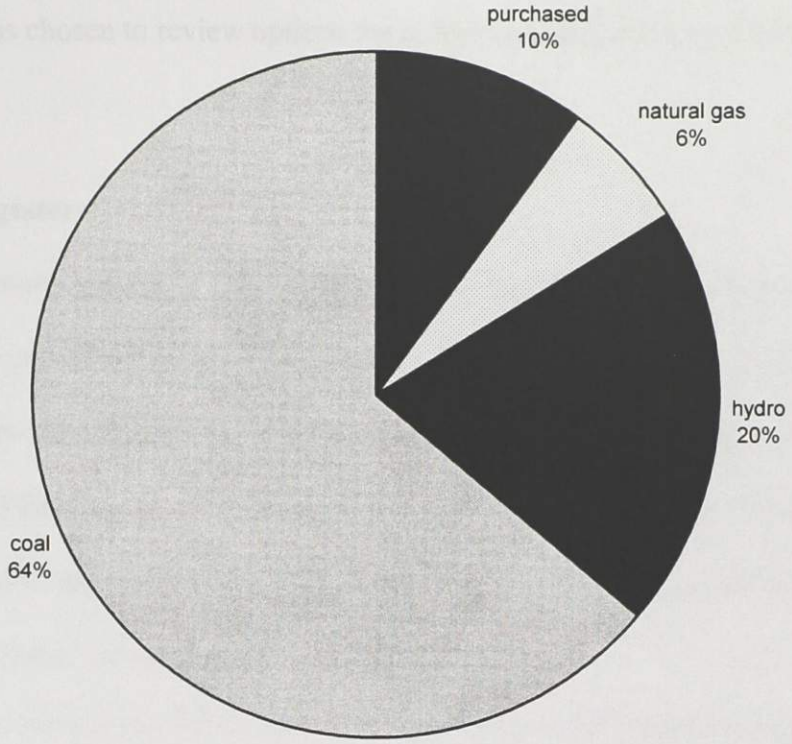



**Figure 1.2 Saskatchewan's Sources of Electricity in 1995**

Source: adapted from SaskPower 1999 Annual Report.

Emissions of GHGs from coal fired electricity generation are 67% higher (1.2 kg of $CO_2$ per kWh) than those from combined cycle[2] natural gas (0.4 kg per kWh). If, in the future, stronger GHG regulations are put in place SaskPower, as an electrical utility,

[2] Waste heat in the exhaust gas of the gas turbine is captured in the form of steam in a heat recovery steam generator. The steam is then used in a steam turbine generator to produce even more electricity. The efficiency of a combined cycle plant is in the range of 45-50%, or 1/3 to 1/2 more useful energy from the same fuel as a simple cycle plant.

potentially faces penalties due to its emissions of GHGs. Hence, SaskPower may have an incentive to change its generation process. In response to this uncertainty SaskPower has chosen to review options for reducing or offsetting its GHG output.

## 1.1 Biodigesters

One approach SaskPower has chosen to focus upon is manure biodigester facilities (biodigesters) juxtaposed to hog operations as a means of electrical generation and GHG reduction. This entails a fundamental departure from the existing business relationship between SaskPower and its customers. Given biodigester technology, SaskPower has the potential to divest itself of part of its generating capacity and supplanting it with microturbine district energy provision (DE)[3].

The processing of hog barn manure via biodigesters is believed to enable SaskPower to offset some of its coal-fired capacity. This is achieved by diverting the GHGs emitted from hog production into the consumer stream in the form of electricity and fertilizer. These processes transform GHG emissions from hog production to a more benign form, hence potentially earning carbon credits for the owner of the biodigester.

## 1.2 Problem Statement

The relationship between SaskPower and other economic actors in the supply chain is linked through the biodigester and represents new transactions. These new transactions require new institutions, or adaptation of existing institutions. Hence, an appropriate institutional framework must be in place to assure a mutually acceptable

distribution of risks and benefits for economic agents. Since property ownership underlies all economic questions of institutional relationships (Hobbs, 1996), the purpose of this study will be to determine a superior organizational form to govern biodigester transactions with supply chain transaction partners from among the six alternative biodigester ownership schemes. These ownership schemes will be compared based upon incentives for opportunism for the applicable transactions.

1. SaskPower purchasing GHG credits from the barn/biodigester as an outside party.
2. Hog barn operates the biodigester as a joint venture with SaskPower.
3. A third party manages the biodigester as a joint venture with SaskPower.
4. SaskPower vertically integrates both hog production and the biodigester.
5. SaskPower owns and operates the biodigester.
6. Hog barn and biodigester are operated as a joint venture for SaskPower and a hog barn management firm (HBF).

The issue of this thesis is to identify the most transaction cost efficient means to minimize opportunism given the set of transactions encompassed in the biodigester supply chains. What sets this research apart from previous studies using transaction cost economics is the examination of situations involving several interlinked transactions. Traditionally, transaction cost literature has examined situations involving only a single transaction (i.e. costs and potential sources of opportunism between an electrical generator and a coal mine involving the exchange of coal between the mine and the generator but no other exchanges are made between the two economic agents.)

[3] Micro-turbine district energy is defined as small generating facilities at close proximity to customer demand.

This study of biodigesters entails a situation of multiple transactions including, GHG offsets, electricity, and the flow of manure between barn and biodigester. This complicates the analysis and requires a close examination of the transactions and their related costs. This process should assist in identifying a superior institutional structure to govern the multiple transactions or to layout exactly the tradeoffs among institutional forms if there is no clearly superior form.

## 1.3 Objectives

The objective of this research is to evaluate a set of potential institutional arrangements to optimize incentives for the development of biodigester facilities in Saskatchewan. By using a Transaction Cost Economics approach the incentives for opportunism will be evaluated given the six different ownership schemes listed in Section 1.2. Since the biodigesters produce three outputs: energy, NPK concentrate[4] and carbon-credits, a matrix of options reflecting the nature of these markets will be created. The multiple markets and varying degrees of asset specific relationships lead to complex relationships that are not typically modeled in economics. Given this framework, the objectives are:

- To present how biodigesters can be used to potentially reduce SaskPower's GHG output.
- To simulate six ownership structures and compare them based upon propensity for opportunism.

[4] NPK concentrate is the solid material containing nitrogen, phosphorus and potassium that is removed from the manure slurry after biodigester processing. The liquid material removed from the slurry is referred to as *grey water* and dealt with later in this thesis.

- To propose and model a transaction cost minimizing institutional structure for biodigesters in Saskatchewan.

## 1.4 Scope of Study

This project will deal exclusively with the application of biodigesters in Saskatchewan. This entails environmental, climatic and market features specific to this province. The boundaries of evaluating the application of biodigesters are defined by the limit of SaskPower's electrical jurisdiction. However, the study could be used as a template for future studies of bio-digestion application in other jurisdictions.

## 1.5 Organization of Thesis

The outline of this thesis is as follows: Chapter two presents a background of Saskatchewan electricity and hog production; Chapter three provides an overview of biodigesters as a means of SaskPower achieving Kyoto Commitments; Chapter four is an overview of NIE (New Institutional Economics); Chapter five is an in-depth analysis of opportunism and governance forms. The conceptual framework, entailing a matrix of institutional options, is developed in chapter six to suggest a superior institutional form given the various policy and ownership scenarios. Chapter seven suggests an institutional form for the governance of biodigesters in Saskatchewan. Chapter eight summarizes insights gained and concludes with suggestions for further study.

# Chapter 2: Background of Electricity and Hog Production

## 2.0 Introduction

This chapter is an overview of the industries that are central to the biodigester technology presented in Chapter One. The first section of this chapter outlines the Saskatchewan electrical system, its history, market organization and district energy provision (section 2.1). The second section outlines the development of hog production in Saskatchewan and its potential for district energy provision (section 2.2). The third section of this chapter (section 2.3) highlights uncertainty and the hog market. Section 2.4 concludes the chapter and introduces Chapter Three.

## 2.1 History of Electricity in Saskatchewan

SaskPower has not always been the sole provider of electricity and electrical transmission facilities in Saskatchewan. Electrical services have been available in parts of Saskatchewan since the latter part of the nineteenth century but these services were limited in scale, scope and potential. In 1927, the Provincial government formed the

Saskatchewan Power Resource Commission to study the widespread electrification of the province. Unfortunately, this Commission was put in place less than two years before the onset of the Great Depression, followed by World War II. These events combined to further delay reform of the electricity industry in Saskatchewan. Thus, until the early 1960s most farms in Saskatchewan remained without electricity, while towns and urban centers were powered by stand-alone facilities that were dispersed, isolated and non-integrated. This electrical supply market has been described as an "economic waste spanning over thirty-five years, a time when citizens of the province... utilized energy produced at unnecessarily excessive cost" (White, 1976:49).

The excessive cost can be attributed to the absence of economies of scale typical of electricity provision during that period. Since there were no high voltage transmission wires to transmit electricity throughout the province, power plants were built close to population centers. These plants had to have enough excess generating capacity to maintain consistent service even if their largest generator was out of commission during peak demand (stand by capacity). If the latter were not the case, then electricity would no longer be "uninterrupted" and there would be blackouts. Hence, power plants had to be completely self-contained since there was no other source of electricity for a given market. This excess capacity was expensive to build, maintain and required a lot of labor to operate. Although it may currently be possible to have an integrated system, which includes small generating facilities, there are large "hook up" costs associated with linking small power plants into high voltage grids.

In 1965, Saskatchewan achieved a fully integrated electrical system. This integrated electrical system involves a small number of large generating facilities joined by high voltage power lines. High voltage lines are important due to the physics of electricity. Higher voltages mean that there is less energy "lost" due to resistance of the conductive materials used in the transmission lines. Although it is possible to have an integrated system of small facilities, economies of scale for high voltage lines has tended to be better supported by large generating facilities. Hence, the operations of all plants are synchronized such that they feed a high-voltage network which, in-turn, feeds a low voltage grid from which consumers draw their power.

Although Saskatchewan's integration occurred later than many other areas of the continent, the scenario of an electrical system being integrated from a collection of small isolated systems was common. Throughout North America, as it became technically and economically feasible, isolated systems were replaced with integrated ones and important economies of scale resulted. Electricity provision from a small number of large plants has lower operating and capital costs relative to a large number of smaller plants.

This is for several reasons:

- Larger facilities are located at more favorable locations, i.e. near coal or natural gas reserves. This is because it tends to be cheaper to transport electricity, via high voltage lines, relative to the cost of transporting coal via train or natural gas via pipelines.
- To provide consistent service, an isolated system must have enough spare generating capacity to handle peak demand while having its largest unit generating out of service. This is to maintain continuous service given breakdowns, repairs or spikes in demand.
- Within an integrated system, "stand-by" capacity in any plant is part of the available reserve for all plants in the system. Thus, less total capacity is required and capital

costs are subsequently reduced and reliability is ensured since all plants in the system can assist others experiencing difficulty.

- Labor requirements for a small number of large power plants are less than many smaller plants due to labor saving technologies associated with economies of scale.
- Generating units can be brought into or out of service on the basis of their operating costs. The most economical units can be used to supply the "base load", or minimum continuous power, needed for the system. Units with higher operating costs only need be engaged for peak load times.

(White, 1976)

These factors culminate in a powerful economic argument in favor of integrated systems. Nevertheless, it is helpful, for this thesis, to look at the electricity industry within the context of its components: generation, transmission and distribution.

### 2.1.1 Market Components for Electricity

The electricity market can be divided into three components:

- Generation: Electricity is produced using internal combustion engines, steam turbines powered with steam produced by fossil fuels, nuclear fuels, and various renewable fuels, water or wind driven turbines and photo-voltaic technologies.
- Transmission: Transportation of high voltage electricity across great distances via wires. When high voltage is used there is less electricity "lost" due to resistance in the conductive material.
- Distribution and retailing: By the use of transformers the high voltage electricity from the transmission lines is "transformed" into lower voltages which can be used by residential appliances and industrial machinery. This segment also entails

making arrangements for supplies of power from generators, metering, billing and various demand management services.

These components of the electricity market are technically separable. Hence, there are transactions that must take place between these separate market components. According to Hobbs (1996), vertical coordination is necessary when any production or distribution takes place.

Until recently the means of vertical coordination between generation, transmission and distribution was almost exclusively vertical integration. Vertical integration has meant the elimination of potential opportunism between market components. Stranded assets typify all of the market components. For example, once a coal-fired power plant is built it is immobile and has no alternative uses (the same applies to transmission and distribution systems). Hence, investments, like power plants, are considered "stranded" since they have a very low salvage value.

Thus there is a:

> ...mutual dependency between seller and buyer for each of these transactions. While it is technically possible to have competing transmission systems that could eliminate dependency, the high costs of such duplication prevent it from being considered as a serious option. The dependency between seller and buyer leaves the door open for opportunism. (Hulleman and Kerr, 1998:242)

To coordinate all the market components involved in the seamless provision of electricity, incentives for opportunism must be limited. Therefore, this supply chain may be thought of as a quintessential example that warrants vertical integration.

As vertical integration of the electricity industry precludes normal market competition, monopolization (either via a regulated monopoly or government ownership) of all three components has been the common industrial structure. Some electrical jurisdictions represent exceptions to the monopoly held / vertically integrated electricity market. In these cases, the components may have different owners but the jurisdiction's government regulates the pricing and service interruptions between components. However, since Saskatchewan is currently a monopoly structure, it is the organizational form assumed to be prevalent for this thesis.

## 2.2 Electricity: Monopoly and Market Reform

The demand and provision of electricity is distinct from most other commodities. Both residential and industrial consumers make their lifestyle and production decisions based upon the assumption of instantaneous gratification of their electricity demands when they flip a switch. When electricity is no longer wanted the switch is turned off and that specific transaction is terminated. The consumer realizes the transaction's initiation and termination at the end of the month as a charge for the amount of electricity consumed while the switch is on. There is no negotiation of prices and, so long as the bill is paid on time, no legal wrangling.

The market for electricity throughout North America developed as monopolies subject to either government regulation or government ownership. Retail customers have purchased their electricity from their regulated monopoly supplier with the legally entrenched right and obligation to supply. This form of market organization has proven adequate to provide consumers with dependable low-cost electricity. However, the

advent of new technologies for generation and distribution as well as the political push from industrial customers, independent power producers and new electricity marketers to impose greater efficiency on the system has resulted in some deregulation of the market. This has brought to the fore two forms of market coordination: transmission access and wheeling.

### 2.2.1 Transmission Access and Wheeling

Transmission access is a form of regulation that is designed to overcome problems associated with stranded assets:

> ...the right or opportunity of electricity generation entities to use transmission facilities owned by others.
> (National Energy Board, 1992)

Wheeling is another form of regulation designed to overcome the stranded asset problem for generators and to remove monopoly power of transmission firms for distributors or final consumers:

> ...the authorized use of the transmission facilities of an intermediate entity by two other entities whose transmission facilities are not directly connected.
> (National Energy Board, 1992)

### 2.2.2 Saskatchewan Electrical Market Paradigm

The current market in Saskatchewan most closely resembles that of *Transmission Access*. SaskPower is the only seller of electricity in the province and most electricity that is consumed within the Saskatchewan Provincial jurisdiction is

generated, transmitted and distributed by SaskPower. However, given trends toward market reforms in other electrical jurisdictions as well as technological developments and potential climate change legislation there are new incentives for SaskPower to change its market paradigm. This entails expanded interests in IPPs[5] (and district energy production) and to allow these generators to use SaskPower transmission facilities.

### 2.2.3 IPPs and District Energy

Independent Power Producers (IPPs) tend to be either cogenerators or small gas fired units with smaller generating capacities than SaskPower's base load generators. For example, SaskPower operates coal fired facilities with greater than 300 MW capacity while IPPs often have less than 500 kW capacity. Historically, economies of scale has dictated that larger power plants can more cheaply provide electricity than many smaller plants. However, the advent of new natural gas fired turbines steadily reduced the capital and operating costs for small-scale facilities. This has allowed smaller companies to enter into the electricity market. The lower start up costs, and less need to locate near fuel sources, has given IPPs a new market advantage for district electricity provision.

District energy consists of industries producing some or all of their electricity needs as part of their normal operations. The advantage of this to a utility like SaskPower is to divest itself of some of the demand on its existing and future generating

[5] IPP refers to independent power producers and is described in detail in section 2.2.3.

capacity. In the case of hog barns, large amounts of heating and electricity are needed to maintain normal operations. Since SaskPower is already facing steadily increasing demand for electricity, self-provision of power by biodigesters may offer an opportunity to reduce its climate change impact yet continue to provide electricity to the province.

### 2.2.4 Current SaskPower Policies toward IPPs

The monopoly and monopsony position of SaskPower allows it to dictate the terms of the agreement it has with any IPP in the province. SaskPower has divided IPPs into two broad categories. Small power producers who have capacities up to 100 kW and large power producers with capacities greater than 100kW.

SaskPower has defined rules for purchases from Small Producers as:

> All electricity supplied will be bought at $0.02 per kWh regardless of when it is provided.
> (SaskPower Annual Report, 1999)

Small power producers must pay for all interconnecting costs including two-way metering to measure the amount of electricity flowing into the grid from the small producer and vice versa.

Each purchase agreement is updated annually to ensure that the small IPP meets all requirements for safety, power quality and grid system security. This is to ensure that no complications from unmaintained small producer facilities threaten SaskPower's obligation to serve.

Agreements for large IPPs are negotiated on an individual basis. For example, the 215 MW Husky Oil – TransAlta Meridian Co-generation plant in Lloydminster has a 25-year agreement stipulating the details of service and purchase obligations to transact 210MW of electrical capacity annually. This capacity is sufficient to generate enough electricity for a city the size of Saskatoon.

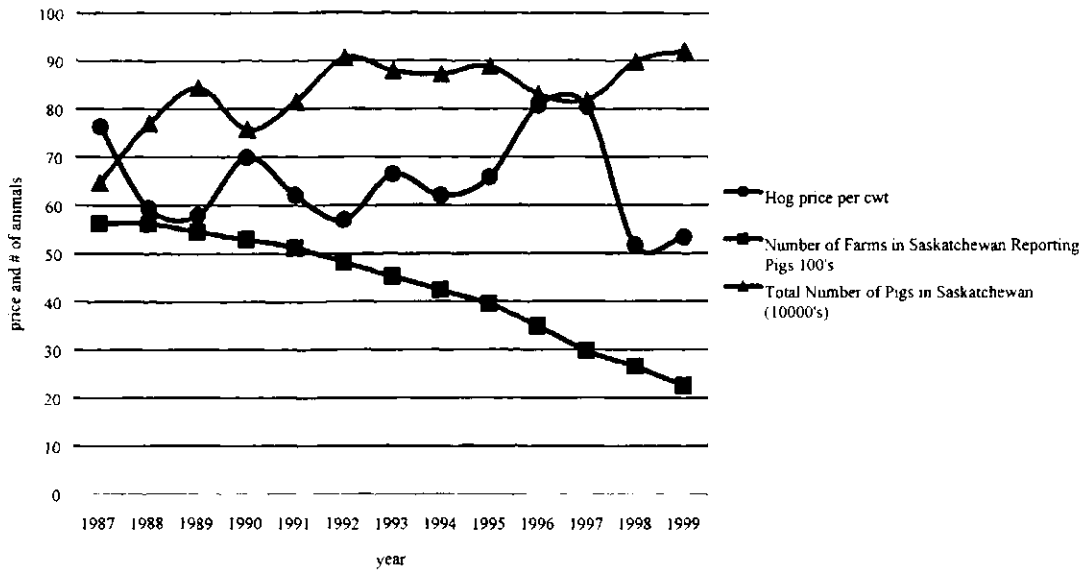
## 2.3 Saskatchewan Hog Production

The development of biodigester technology in Saskatchewan depends upon a source of livestock manure. Thus, it is dependent upon the continuation of structural trends, occurring in the province, for hog production. During the 1990s there was a small but steady increase in the number of hogs in the province and a significant concentration of production into large-scale (more intensive) operations. (See Table 2.1 and Graphs 2.1 and 2.2)

**Table 2.1 Number of Hogs in Saskatchewan**

| Year | Average Number of Pigs Per Saskatchewan Farm | Number of Farms in Saskatchewan Reporting Pigs | Total Number of Pigs in Saskatchewan |
|---|---|---|---|
| 1987 | 115 | 5,620 | 646,300 |
| 1988 | 137 | 5,620 | 769,940 |
| 1989 | 155 | 5,450 | 844,750 |
| 1990 | 143 | 5,290 | 756,470 |
| 1991 | 159 | 5,130 | 815,670 |
| 1992 | 188 | 4,820 | 906,160 |
| 1993 | 194 | 4,530 | 878,820 |
| 1994 | 206 | 4,240 | 873,440 |
| 1995 | 225 | 3,950 | 888,750 |
| 1996 | 238 | 3,490 | 830,620 |
| 1997 | 275 | 2,975 | 818,125 |
| 1998 | 339 | 2,650 | 898,350 |
| 1999 | 410 | 2,250 | 922,500 |
| 2000 | 540 | 1,780 | 961,200 |

Source: Banks, (2000)




**Graph 2.1 Saskatchewan Hog Production from 1987 to 1999**
Source: Banks, (2000)

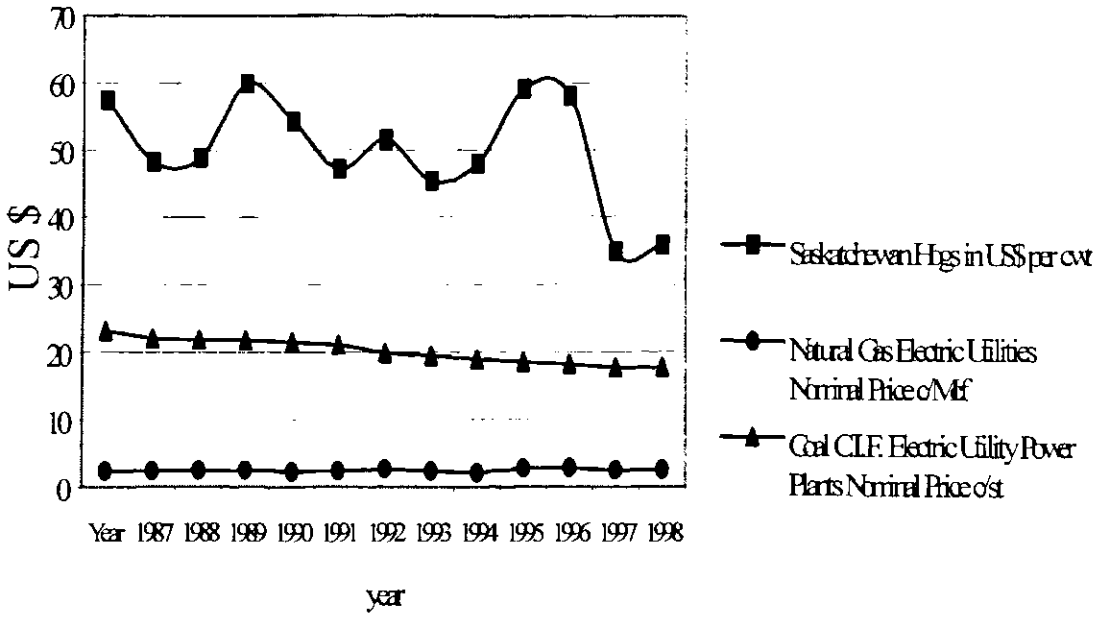
As is indicated by the statistics in Table 2.1, Saskatchewan hog production has shifted from an industry typified by many small and probably unspecialized producers to a specialized industry. The industry has adopted large-scale production units with large demands for heating, electricity and specialized manure management systems to handle waste. Such changes in hog production open an opportunity for district energy provision. This entails the hog barn providing a portion, or all, of its electricity requirements. Much of the previous material has supported the case for integrated electricity provision; however, pressures from new climate change legislation and regulatory developments provide a potential symbiosis between SaskPower and large hog operations. Such a relationship may mitigate SaskPower's obligation to increase its generating capacity and allow it to accrue carbon offsets. This will be discussed in further detail in Chapter Three.

## 2.4 Uncertainty and the Hog Market

The primary goals of SaskPower, in its plans for biodigesters, have been assumed to be the generation of carbon credits and the production of electricity. In either case, the production of these outputs relies on the supply of manure from the hog barn and is, hence, directly dependent on the supply of hogs. For example, if a barn experiences financial difficulty due to a depressed hog market, the logical recourse might be closure. This action would terminate the flow of manure to any adjacent biodigester. The biodigester would be unable to function without this flow of manure and transportation of manure from other barns would likely be prohibitively expensive.

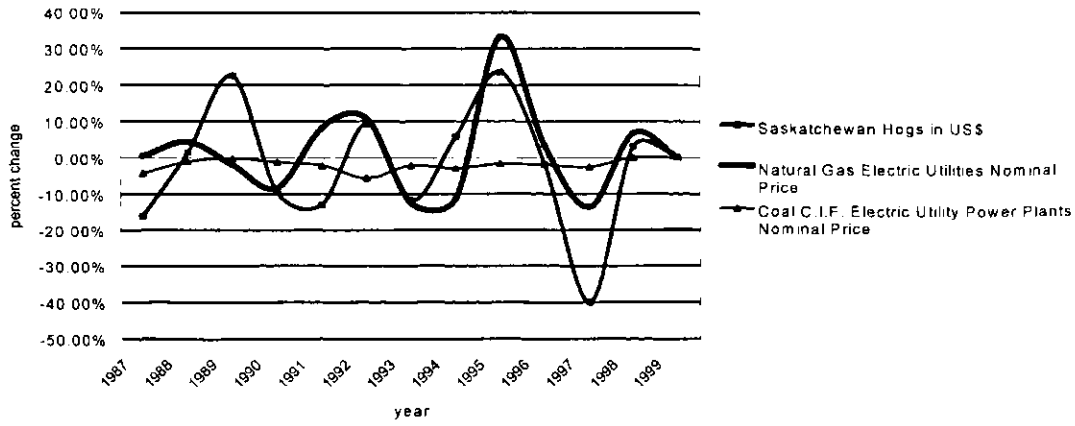
Currently, the majority of SaskPower's generating capacity depends on fossil fuels (coal and natural gas) as its fuel source. SaskPower's experience is in making contracts with suppliers of these inputs has entailed specific asset investments by various parties of the agreement.

The markets for coal and natural gas are subject to price fluctuations. This is accounted for within SaskPower's purchase agreements. However, if SaskPower were to model its business practices such that it depends on the hog market for carbon credits and electricity to allow normal business operations, then SaskPower would be subject to the hog cycle. Comparisons of price fluctuations in the hog versus the petroleum market are illustrated in graphs 2.2 and 2.3.




**Graph 2.2 Prices hogs vs. Petroleum 1987 to 1999**

Source: Adapted from Banks, (2000)




**Graph 2.3 Percent Change in Prices for Hogs vs. Petroleum 1987 to 1999**

Source: Adapted from Saskatchewan Statistics Bureau, (2000)

Prices for these petroleum inputs express cyclical price variation similar to that of the hog industry. This is not immediately noticeable in graph 2.2 due to differences in the magnitude of prices, however, it can be better observed when represented as percentile changes as in graph 2.3.

Coal prices have undergone little price variability over the relevant period. However, both natural gas and hogs experience similar percentile magnitudes of change over time. This could imply that the level of uncertainty of prices for hogs and natural gas would be similar if SaskPower were to consider hogs as an energy source relative to their existing reliance on natural gas. Such an assumption can be made since the market structure and the existence of established rules for the distribution of natural gas exist while that for the generation of electricity from hog manure is not. The natural gas industry in Saskatchewan is characterized by many gas wells supplying the TransGas pipeline infrastructure. Thus, SaskPower enters into supply arrangements between gas producers and TransGas. Supply or demand disputes are handled by an established arbitration system that is supported by the Canadian legal system.

For the supply of energy from hog barns linked to biodigesters, there is no arbitration or legal mechanism currently existing. Given that there are many hog barn / biodigester systems supplying electricity it is difficult to negotiate arrangements for the consistent supply of energy needed by SaskPower to satisfy its obligation to serve. To depend on hogs to maintain their service capacity (via either GHG credits or as an electricity source) SaskPower would be subject to the price fluctuations of the hog market.

## 2.5 Uncertainty and SaskPower

The role of uncertainty for SaskPower can not be overstated. Currently, SaskPower operates in a monopolistic market with little uncertainty. However, by relying on biodigesters to provide either electricity or carbon credits, SaskPower would be depending on a market characterized by far more uncertainty and variability than is the case with its current monopoly status. Despite these challenges, biodigesters are an option being considered by SaskPower. Therefore, further economic analysis is appropriate.

## 2.6 Conclusion

This chapter has reviewed the history and current electrical generation practices for Saskatchewan including that of IPPs. This was followed by a presentation of trends of swine production in the province and a comparison of historical prices for hogs relative to coal and natural gas. Chapter Three is devoted to examining the applications, definitions and concepts applicable to bio-digestion as it relates to electricity and swine production as well as how it pertains to climate change.

# Chapter 3: Biodigesters as a Means of Achieving Kyoto Commitments

## 3.0 Introduction

This chapter describes how biodigesters can contribute to the achievement of Kyoto levels of GHG emissions. The emphasis is upon GHG emissions associated with both electricity and hog production in Saskatchewan. Current practices will be contrasted with those using biodigesters as a means of reducing GHG emissions.

This chapter begins with explanations of the rationale behind researching biodigesters in Saskatchewan, how biodigesters work and the end products of the processes (Section 3.1). The following section presents how biodigesters would be combined with Saskatchewan hog-operations as a means of economic development in Saskatchewan (Section 3.2). Subsequently, Section 3.3 will focus upon how biodigesters can be used as a value-added method of manure management with particular emphasis on GHG reduction. Section 3.4 describes how biodigesters can be used for GHG reduction. Section 3.5 concludes the chapter and introduces Chapter Four.

## 3.1 Biodigesters

Biodigester technology for converting manure into methane for fuel is neither new nor uncommon. In many parts of Asia, Central America and Europe biodigester use is widespread. Biodigesters are applied in these areas in response to organic waste (manure) disposal problems and/or high-energy costs. At this point in time Saskatchewan faces neither of these problems. In fact, Saskatchewan is characterized by relatively low energy prices and has a vast agricultural land base upon which to apply manure. However, given the possibility of future climate change legislation, the cost of GHG emitting activities like coal fired electrical generation and manure spreading will likely increase. Thus, the incentive for researching bio-digestion, as a means of energy production and waste disposal, is to ultimately achieve reductions in GHG output without undue increases in the cost of electricity.

### 3.1.1 The Process Inside Biodigesters

The process of bio-digestion is the collection of organic material into a containment body, which is isolated from the external environment. Within this body a microenvironment optimal for methanogenic bacteria (methanogens[6]) is provided. These methanogens digest organic material (in this case manure) and emit $CH_4$ gas and NPK slurry[7] (NPK concentrate[8] and grey water[9]). This process greatly reduces the

[6] Methanogens are anaerobic bacteria, which digest organic material and release methane as a byproduct.
[7] NPK slurry refers to the liquid material that has passed through the biodigester. It is a mixture which, when separated, constitutes NPK concentrate and grey water.
[8] For this thesis NPK concentrate is not intended to mean the final commercial product, rather it refers to a product that can be used as input for the production of a commercial product like compost.
[9] Grey water is the water that is removed from the NPK slurry. This water might be purified to potable standards, however, this has yet to be verified by independent study.

emission of volatiles[10] normally associated with manure and converts the solids into a more uniform sterilized product. Carbon that normally would be released in the form of gaseous hydrocarbons, $CO_2$ and $CH_4$, is contained and burnt as fuel to heat the barn and biodigester. If the gaseous hydrocarbons are burnt in a microturbine[11], then electricity to power the barn and biodigester facilities can also be generated. The residual heat from the microturbine is available to maintain a consistent climate within both barn and biodigester (see Figure 3.1).

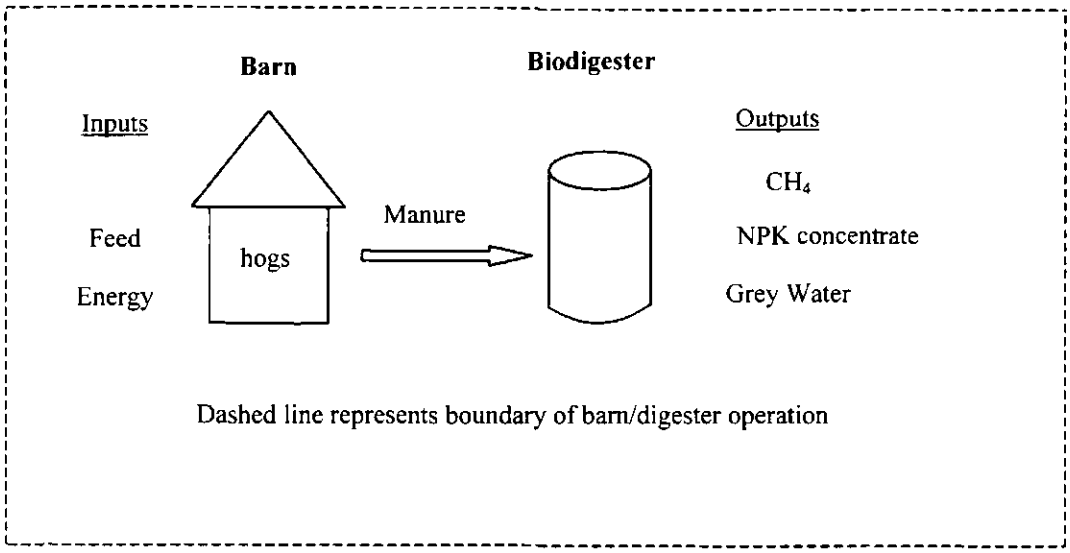



**Figure 3-1 Biodigester Schematic**

### 3.1.2 Emissions from Current Saskatchewan Hog Production

Hog production in Saskatchewan is increasingly done in large intensive operations that house over 500 sows. Emissions of GHGs from hog production occur in the three main stages of the manure handling process; in the barn; in the lagoon; when manure is applied to agriculture land (as illustrated in Figure 3.2).

[10] For this thesis volatiles are gaseous substances like $NH_3$, $CH_4$, $CO_2$, or $N_2O$ which are emitted from manure.
[11] Microtubine: For this thesis shall refer to a small, portable gas-fired electricity generating plant of 75kW capacity.

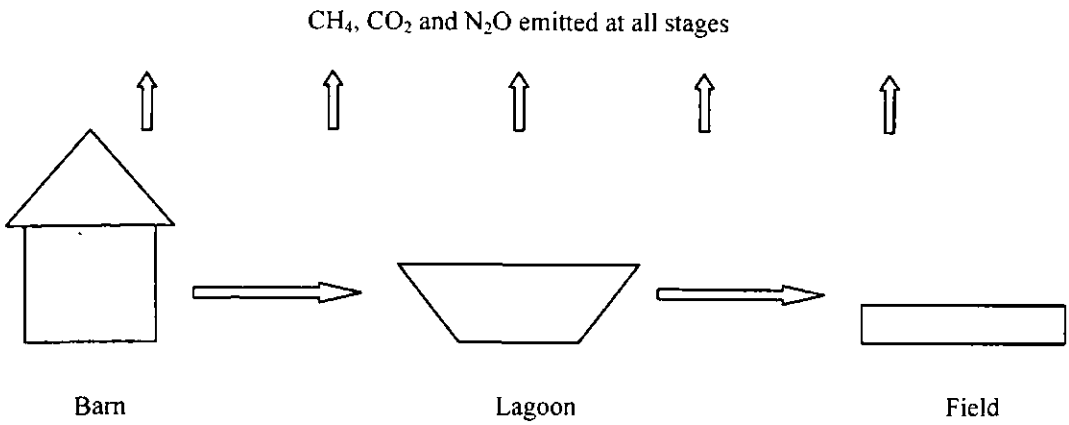



**Figure 3-2 Emissions Schematic**

The amount of GHGs emitted at each stage is a function of temperature, exposure to air and time spent at each stage, and the initial chemical properties of the manure.

| | |
|---|---|
| Exposure to air: | Both aerobic and anaerobic bacteria emit different relative amounts of $CH_4$ and $CO_2$, respectively, while they decompose manure. This pertains to all three stages of the manure management system, however, is most relevant during lagoon storage. Since lagoons are deep and manure does not circulate well, most of the manure is not exposed to air; thus, anaerobic bacterial processes are predominant. Since relative emissions of $CH_4$ are much higher for anaerobic bacteria, the GHG impact from these processes will be higher. |
| Temperature: | For biodigesters, methanogenic microbial growth (hence, activity) takes place between $10^0$C and $45^0$C and optimal growth takes place between $30^0$C and $35^0$C (Coxworth 2000). Within these temperature ranges emissions vary greatly. Thus, external temperature changes, diurnally[12] or annually, can seriously affect the amount of $CH_4$ produced. |
| Time: | The amount of time spent at each manure management stage affects the amount of GHGs released by the bacteria. For example, if manure sits in a lagoon for many months then anaerobic bacteria will emit a great deal of $CH_4$. However, if manure is applied to fields, without prolonged lagoon storage, much of the organic hydrocarbon compounds will be incorporated in the soil. |
| Manure Properties: | The constituent properties of the manure are affected by the feeding regime[13] for the animals. This, in turn, affects bacterial activity and the manure GHG potential |

Variability of emissions throughout the manure handling process introduces a great deal of complexity when formulating a GHG reduction strategy. To provide a mutually acceptable reduction value, to whatever governing body[14] is responsible for monitoring reductions, a baseline[15] value is necessary. From the baseline, removal or abatement of the GHG emitting process is treated as the GHG reduction. However,

[12] Diurnally, to occur over the period of a day.
[13] Feeding regime: the amount of elements such as nitrogen in the feed is reflected in the manure. Similarly, if the animals are treated with antibiotics this will be reflected in the manure and, hence, the health of the digesting bacteria.
[14] Governing body: an organization, public or private, which monitors and approves GHG reductions and offsets.

given the potential variation in GHG emissions owing to the variety of possible temperatures, feeding regimes or the quantity of time the manure is at any stage of the manure management process, a mutually acceptable baseline is not easily definable.

### 3.1.2 Energy Balance

The energy balance for biodigesters is the ability of the biodigester system to produce enough energy to have excess energy for sale, to be self-sufficient or to require energy from an outside source. As was discussed in the previous section, there are several factors affecting the biodigester's ability to operate effectively. Since biodigesters have yet to be proven as an appropriate technology for Saskatchewan, it is difficult to speculate if these systems will be able to provide surplus energy throughout the year or if they will require supplemental energy during some times of the year.

### 3.1.3 Hypothetical Hog-Barn and Biodigester Enterprise

Application of bio-digestion to Saskatchewan hog operations entails on-site self-provision of energy. This energy is produced via digestion of the manure into $CH_4$ gas. The burning of $CH_4$ provides heat and/or electricity for the barn/biodigester (as illustrated in Figure 3.3).

[15] Baseline: a GHG emission value, which is treated by the governing body as the accepted industry

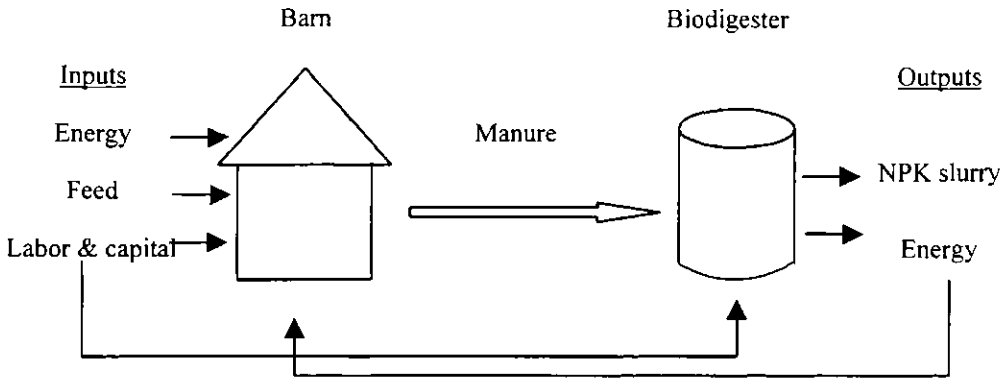



**Figure 3-3 Hypothetical Biodigester**

## 3.2 Biodigesters as a means of Saskatchewan Economic Development

The Saskatchewan economy may experience economic hardship given higher production costs arising from climate change legislation. Saskatchewan is a capital intensive resource based economy that relies on inexpensive energy as an input for agriculture, mining and fertilizer production. Bio-digestion could help mitigate increased energy costs by reducing demand on electricity and natural gas resources.

As illustrated in Figure 3.3, biodigesters produce heat and electricity, which enable expansion in the hog industry without placing further demands on existing natural gas or electricity resources. Also, biodigesters produce a consistent NPK fertilizer product, which may be used in either agriculture or landscaping. Currently, undigested manure is injected[16] into fields in its raw liquid from. Clearly this raw manure is a valuable resource; however, its value can be augmented via digestion.

standard.

[16] Injection is a method of manure application that uses apparatus similar to an air seeder to place manure below the surface.

### 3.2.1 Hog Manure as Fertilizer

The transformation of prairie swine production from many small, non-specialized producers to large scale operations dominating the production landscape has led to problems associated with the concentration of manure in areas surrounding intensive hog barns. Although the prairies have extensive agriculture land resources requiring fertilizer, the high weight to nutrient ratio of manure slurry precludes transportation for any significant distance.

### 3.2.2 Water and Air Quality

Intensive hog operations continually receive complaints regarding the quality of air and water proximate to the barn. Such concerns have been heightened since the Walkerton Ontario case of e-coli contamination of the local water supply, May 2000, which resulted in the deaths of 6 people. Although intensive livestock operations have not been positively linked to the contamination, concerns over livestock manure management have become more pronounced. The possibility of similar incidents occurring in the future may press federal, provincial or municipal governments to implement stronger livestock manure management legislation. Hence, it is conceivable that new taxes or environmental charges would be implemented based upon output and management of livestock manure.

## 3.3 Biodigesters as a Value Adding Means of Manure Management

Biodigesters have been suggested as a way to alleviate pollution concerns as well as offering new revenue opportunities. These opportunities are realized via the fertilizer market, the energy market and GHG credits.

### 3.3.1 Fertilizer

One product of bio-digestion is the conversion of raw manure slurry into enriched NPK fertilizer. Relative to raw manure the enriched NPK concentrate has more available nutrients, is relatively odorless, is free of disease, germs, weeds, seeds and is less prone to cause water contamination (Hazeltine and Bull, 1999). Hence, the digested product is characterized by greater consistency and minimizes offensive odors. In effect, a biodigester is an environment that transforms carbon and hydrogen in the raw slurry[17] into gaseous $CH_4$ for combustion. The remaining liquid mixture is sterilized and rendered into a consistent NPK concentrate via bacterial activity. The liquid NPK fertilizer can then be de-watered to become NPK concentrate. The latter process adds significant value since water is heavy and expensive to transport. When water is removed only the nutrient rich solids remain and can be transported longer distances at less cost. The residual "grey" water can possibly be used to flush manure from the barns into the biodigester.

[17] Raw slurry is unprocessed liquid manure.

These factors combine to alleviate the problem of excessive fertilization close to the hog barns and opens opportunities for hog manure in the higher value residential compost market.

### 3.3.2 Energy

Energy from biodigesters is realized by burning the $CH_4$ from the biodigester to fire microturbine electrical generators and/or furnaces. This heat and electricity is subsequently used to power hog barn and biodigester operations and residual electricity can be fed into the existing grid.

Estimated generating capacity for biodigesters is in a range between 75kW per 750 hogs (0.1 kW per animal) (Kline,[18] 2000) to those from Ben Voss of BDI (Saskatoon engineering firm) of 250kW to 2MW per 1200 animals (0.21kW to1.67 kW per animal). The latter number, from BDI, is 17 times that of the initial estimate from Kline. This implies that the latter estimate is somewhat optimistic. Thus, the estimate from Kline and the pessimistic estimates from Kline and Voss would require between 29 million and 14 million hogs, respectively, to generate the equivalent of SaskPower's current generating capacity. Recall from Chapter 2 that there were less than one million hogs in Saskatchewan in 2000. Therfore, it is unlikely that SaskPower is considering offsetting all of its generating capacity via hog barn biodigesters

Given that hog barn biodigester facilities have estimated generating capacities ranging from 75kW per 750 animals (0.1 kW per animal) (Kline, 2000) to 250kW per

1200 animals (0.2kW per animal) (Voss, 2000), self-provision of energy seems plausible. However, this may represent net self-provision. The ability of the biodigester to make methane could vary greatly depending on the temperature of the external environment. Thus, it may produce an excess of methane during the summer but may require outside energy inputs during the winter. Storage of the methane may be an alternative to balance these annual variations.

There have been suggestions that electricity from the biodigester could be fed into the consumer stream via the existing electricity grid. Although this is technically possible, many hurdles exist. In Saskatchewan, SaskPower retains monopoly and monopsony power over all purchases and sales of electricity. SaskPower's Small Producer Program purchases any, or all, electricity from IPPs with less than 100kW capacity for $0.02 per kWh. The contractual arrangement for purchases from small producers is renewed annually subject to SaskPower's discretion.

Another consideration is the cost of hook up to the main grid. The electrical voltage which is usable by domestic and industrial appliances (lights, fans, etc) is not the same voltage as that which travels in transmission or distribution lines. As a result, transformers are used to convert the electricity from transmission voltage to domestic (industrial) voltages. Thus, any electricity produced by the biodigester facility must be converted via a transformer and the biodigester must pay the expense. This demonstrates that the generating capacity of a single, or even a group of barns, is very small so it is unlikely to factor prominently in SaskPower's operating decisions.

[18] Mr. Kline is the president of a Calgary based electricity firm, Mercury Electric, which is interested in developing biomass electricity generation.

At first glance the Small Producer Program may seem like an unrealistic impediment to IPPs. However, SaskPower has an existing generating capacity of 2889 MW (SaskPower Annual Report, 1999) and the generating capacity from individual biodigester systems is very small by comparison. Thus, it would seem unlikely that SaskPower would want to put into question their mandate to provide uninterrupted service by relying on unproven technology, like biodigesters, when there are many other forms of alternative energy generation (i.e. wind or industrial co-generation).

SaskPower would have to maintain enough reserve capacity to provide uninterrupted service with or without the contribution of the hog barn biodigesters. Therefore, prudence dictates that bio-digestion would be better looked upon firstly as a means of energy self provision and it is probably unrealistic to think of them as suppliers of electricity to the main grid.

### 3.4 Bio-digestion for GHG Reduction

This thesis was prompted by SaskPower's interest in reducing its GHG emissions. The Kyoto Protocol used 1990 as the base line for GHG reductions. During the time period between 1990 to 2000, SaskPower realized a 37% increase in GHG emissions (measured in $CO_2$ equivalents). Much of this increase has been due to SaskPower bringing the Shand Power Station online in 1992. Building of this 300 MW facility was started in 1988 and although it is a very modern facility with relatively low emissions, the timing of commissioning was unfortunate since the baseline selected by the Kyoto round was 1990.

**Table 3.1 Total SaskPower $CO_2$ Emissions**

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Emissions | 10.6 | 10.8 | 12.3 | 13.2 | 13.9 | 13.8 | 14.4 | 14.5 | 14.8 | 15 | 14.5 |

Source: SaskPower Climate Change Action Plan 1998/99 Update (in Megatonnes)

It remains uncertain if the Federal government intends to realize its Kyoto Protocol commitments by mandating a 6% GHG emissions reduction from 1990 levels on all emitting firms. Nevertheless, application of a 6% GHG reduction by 2012 would mean that SaskPower GHG output would be reduced to 10 Mt.

$$\text{1990 emissions} = 10.6\text{Mt } CO_2 \tag{3.1}$$

$$\text{Emissions 6\% below 1990} = (10.6 \text{ Mt} * 0.94) = 9.96 \text{ Mt} \tag{3.2}$$

There are three means by which bio-digestion may be viewed as a carbon reduction mechanism:

- By reducing demand on the existing SaskPower generating facilities;
- Supplanting fossil natural gas, which would have been burnt to heat barns;
- By transforming the manure management style currently used in Saskatchewan into one with fewer GHG emissions (bio-digestion), then taking the difference of the two management styles as a GHG emission reduction.

### 3.4.1 Reducing Demand on the SaskPower Grid

Electricity for hog barns is currently drawn from the power grid. However, if hog barns were able to provide some, or all, of their electricity needs via bio-digestion, then less pressure would be placed upon the existing coal fired electrical plants.

By assuming that biodigesters are feasible, then they could reduce the demand on conventional coal or natural gas fired generating capacity that would translate into a reduction in GHG output.

In the event that SaskPower would face taxes or, have to purchase carbon credits, the cost of producing electricity would increase. Thus, if hog barns choose to juxtapose biodigesters to their operations then SaskPower would not have to incur capital costs of retrofitting for natural gas generation or incur penalties for emitting GHGs for the energy used by hog barns.

### 3.4.2 Reducing Demand on Fossil Natural Gas

Methane produced from bio-digestion of hog manure could be used to offset fossil natural gas used for heating the hog barn. This reduction in fossil fuel may be considered a GHG reduction by taking the difference between business-as-usual natural gas consumption ($BAU_{ng}$) and consumption after application of biodigester technology ($BA_{ng}$).

$$\text{Reduction} = (BAU_{ng}) - (BA_{ng}) \qquad (3.3)$$

However, this would have to be approved as a reduction by an empowered climate change governing body.

### 3.4.3 Biodigesters as an Offset Mechanism

The current manure management system utilized by prairie hog producers emits GHGs ($CH_4$, $CO_2$, and $N_2O$) in the barn, during lagoon storage and after it is applied to agriculture land. Bio-digestion offers a means of converting carbon in the manure into gaseous $CH_4$ for burning and stabilizing the constituent elements in the previously volatile slurry. Thus, if biodigesters were seen as a manure management system, which diverts otherwise emitted GHGs into $CH_4$ and NPK fertilizer, it would be seen as a GHG reduction.

The IPCC criteria[19] that $CH_4$ emissions from conventional swine production in North America are 10 kg/head/year for a cool climate[20]. The values for $CH_4$ are presented in Table 3.2 and their $CO_2$ equivalents are presented in Table 3.3.

**Table 3.2 Manure Management Emission Factors for Swine**

| Regional Characteristics | Livestock Type | Emissions of $CH_4$ (kg/head/year) by Climate Region | | |
|---|---|---|---|---|
| | | Cool | Temperate | Warm |
| North America: Liquid manure based systems are commonly used for Swine. | Swine | 10 | 14 | 18 |

Source: IPCC Technical Support Unit, (1999)

[19] These IPCC criteria are estimates based upon industry averages.
[20] Cool climate is defined in IPCC guidelines as having an annual average temperature bellow 15°C. The average annual temperature in Saskatoon is –1°C.

**Table 3-3 Relative Global Warming Potential**

($CO_2$ equivalents per unit mass of GHG)

| Gas | Time Horizon | | |
|---|---|---|---|
| | 20 year | 100 year | 500 year |
| $CO_2$ | 1 | 1 | 1 |
| $CH_4$ | 56 | 21 | 6.5 |
| $N_2O$ | 280 | 310 | 170 |

Source: Adapted from R.L. Dejardins, AAFC, (1988)

The accepted value for converting GHG global warming potential is the 100 year time horizon[21]. Hence, one unit of $CH_4$ is treated as being the equivalent of 21 units of $CO_2$.

**Table 3-4 $CO_2$ Equivalent Manure Management Emission Factors for Swine**

| Regional Characteristics | Livestock Type | $CO_2$ Equivalent (kg/head/year) by Climate Region | | |
|---|---|---|---|---|
| | | Cool | Temperate | Warm |
| North America: Liquid manure based systems are commonly used for Swine. | Swine | 210 | 294 | 378 |

Source: Adapted from IPCC Technical Support Unit, (1999)

The GHG reduction is calculated by taking the difference between the business-as-usual (BAU) emissions and the emissions given the application of biodigesters.

[21] The potential for this GHG to absorb and remit energy, relative to $CO_2$, over a time period of 100 years.

### 3.3.4 Calculation of Emission Reduction

To calculate emission reduction the starting point is the balanced chemical equation:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \tag{3.8}$$

Where: the result of this combustive reaction is kJ of energy.

The mass of $CO_2$ from the combustion of $CH_4$ is determined from the stoichiometric[22]law at the accepted temperature of $25^0$C (298.15K) and one atmosphere (1 atm.).

$$\text{mols } CH_4 = (10000\text{g } CH_4)\left(\frac{1 \text{ mol } CH_4}{16.04\text{g } CH_4}\right)$$
$$= 623 \text{ mols } CH_4 \tag{3.9}$$

$$\text{mols } CO_2 \text{ produced} = (623 \text{ mols } CH_4)\left(\frac{1 \text{ mol } CO_2}{1 \text{ mol } CH_4}\right)$$
$$= 623 \text{ mols } CO_2 \tag{3.10}$$

$$\text{mass of } CO_2 \text{ produced} = (623 \text{ mols } CO_2)\left(\frac{44.01\text{g } CO_2}{1 \text{ mol } CO_2}\right)$$
$$= 27438\text{g of } CO_2 \tag{3.11}$$

Source: Author's calculations

If the 10-kg of $CH_4$ had been released into the atmosphere it would have a global warming capacity of 210 kg of $CO_2$. However, combusting that amount of $CH_4$ releases only 27 kg of $CO_2$. This is a 7.8 fold improvement in emissions and is a GHG reduction of 183 kg of $CO_2$ per animal.

## 3.5 Conclusion

This chapter has described how biodigesters can be used to reduce GHG emissions. Biodigesters may offer a means by which SaskPower can earn GHG offsets and reduce demand on its current generating capacity. However, the technology is characterized by uncertainty and further research into the technical hurdles would yield more information on this matter.

The next chapter deals with transaction costs terminology pertaining to transaction cost minimizing organizational forms relevant to biodigesters.

[22] Stoichiometry refers to the mass relationships among reactants ($CH_4$ and $O_2$) and products ($CO_2$ and $H_2O$) in chemical reactions.

# Chapter 4: Overview of New Institutional Economics

## 4.0 Introduction

This chapter is an overview of new institutional economics and in particular, transaction cost economics. The concepts detailed in this chapter will be used throughout the remainder of this thesis as the basis of analysis. Section 4.1 outlines the development of new institutional economics relevant definitions. Section 4.2 details how such terminology is used to explain vertical integration in the electricity industry. Section 4.3 provides a description of natural monopoly in the electricity industry. The conclusion, Section 4.4, reviews the chapter and introduces Chapter Five.

## 4.1 Transaction Cost Economics

For economists, neoclassical analysis has tended to be the paradigm used to examine economic behavior. However, the set of assumptions underlying the neoclassical paradigm ignores the intricacies of why and how different forms of business structure are manifested in the market place. In one view, new institutional

economics (NIE) attempts to answer these questions as an augmentation, not a replacement, for neoclassical analysis. It is an augmentation that allows examination of the necessary institutions involved in business activity. Transaction cost economics is an integral part of NIE. This segment of the thesis looks at how transaction costs are likely to influence the institutional arrangements that allow transactions to be realized.

### 4.1.1 Development of Transaction Cost Economics (TCE)

In traditional neoclassical economic analysis no consideration is given to the means by which transactions occur. Firms are propelled by strict profit motives within an environment without uncertainty, where there is perfect information, and where agents produce homogeneous goods, there are no measurement problems, there is no negotiating, no need for monitoring, access to resources is unencumbered and decisions are made independent of the behavior of other agents. In neoclassical economics, transaction costs are considered to be sufficiently small, that they can be assumed away and explanations as to how or why firms transform inputs into outputs is considered unnecessary. Hence, neoclassical analysis has been stylized as the "frictionless" economy in reference to introductory physics models that begin their description of physical processes in the absence of friction. This is done as a simplification to provide a readily accessible framework to initiate thinking about a given subject. However, as has been always been known, economic interactions, just like physical ones, do involve "friction". Nevertheless this "friction" does not render "frictionless" models irrelevant. Rather, it means additional information must be included to gain a more accurate understanding of how economies work.

The origins of TCE are rooted in Ronald Coase's 1937 seminal work "The Nature of the Firm." His insight was to recognize there are organizational costs for firms to transform inputs into outputs and it is these costs that determine how the firm is organized and the boundaries of a firm's internal activities. Firms emerge because it is less costly to organize production by using internal management mechanisms rather than arms length market transactions. Hence, transaction costs can be used as a tool to evaluate why a particular form of market organization (contractual, vertically integrated, etc.) prevails for a given supply chain.

### 4.1.2 Behavioral Concepts Underlying New Institutional Economics (NIE)

There are four key behavioral concepts that underlie NIE:

1. *Bounded rationality*: Neoclassical economics assumes individuals intend to make fully informed and rational decisions. However, with bounded rationality, their ability to evaluate all decision alternatives is limited by their cognitive abilities. In situations of uncertainty, transaction costs must be incurred to obtain information to compensate for these cognitive shortfalls.
2. *Opportunism*: Neoclassical economics assumes opportunism is not possible because with perfect costless information transaction partners would anticipate opportunism and seek out alternative transaction partners. Without perfect costless information, opportunism can be practiced. Opportunism or, "self interest

seeking with guile," becomes particularly important in situations when the "small numbers bargaining problem[23]" applies. (Williamson, 1979)

3. *Asset Specificity*: Neoclassical economics assumes no asset specificity. Asset specificity occurs when one party to a transaction has made an investment specific to that relationship with their exchange partner and that investment has little or no alternative use.
4. *Imperfect Information / Information Asymmetry*: Neoclassical economics assumes perfect information. TCE assumes that either both agents face incomplete levels of information (imperfect information) or agents face unequal access to information (asymmetry).

Adapted from (Hobbs and Kerr, 1999)

### 4.1.3 Classifications of Transaction Costs

Given the four underlying behavioral concepts, transaction costs can be divided into three main classifications.

1. *Information Costs (search costs)*: Costs that arise prior to a transaction due to imperfect or asymmetrical information. Therefore, agents must incur costs to search for information about products, prices, inputs and transaction partners.
2. *Negotiating costs*: These arise from the physical act of transacting and include negotiating and writing contracts plus paying intermediaries.

[23] The small numbers problem is where agents' choices of business partners are limited. As such, economic agents exploit their market position to their own advantage in order to capture rents.

3. *Monitoring and Enforcement Costs*: Ex-post costs incurred to ensure that terms of a contract are honored via monitoring or seeking restitution if a contract is broken

Adapted from (Hobbs and Kerr 1999)

### 4.1.4 The Hold-Up Problem

Faced with uncertainty, parties involved in or considering asset specific investments try to minimize their exposure to opportunism. Opportunism manifests itself when the holder of asset specific investments has only a limited number of buyers or sellers for their output or essential inputs. The hold up problem is characterized as a situation where agents in an agreement are in a position where they can be forced to accept disadvantageous terms once they have committed to transaction specific investments. As the agents realize that they are subject to opportunism, they refuse to invest (or under-invest) as they fear that the potential returns are outweighed by the potential losses due to opportunism.

### 4.1.5 Governance Structure

This is a term coined by Oliver Williamson (1971) to describe the organization of economic activity within an industry. Forms of governance can be viewed as a continuum of market relationships that minimize transaction costs. For example, the electricity market in Saskatchewan represents one pole in the continuum of governance structure. It is typified by full vertical integration where one firm, SaskPower, controls generation, transmission and distribution segments of the industry. Since all three

industry segments are typified by highly specific assets (coal fired generators and transmission lines are expensive to build and have limited salvage value) vertical integration evolved as the least cost means to limit exposure to hold-ups between market segments.

The opposite extremes of governance structure are those prevalent for certain agricultural commodities where, for example, in the Canola market assets frequently have alternative applications, it is a standardized product and there are many potential buyers and sellers. Hence there are spot market transactions where multiple buyers and sellers make exchanges in the current time period in response to market price signals. In-between these two poles exist a plethora of means to coordinate economic activity. Examples include, contracting, strategic alliances, tapered[24] and quasi-vertical integration[25]. (Hobbs and Kerr, 1999)

### 4.1.6 Contract Classifications

Oliver Williamson (1979) used contract law to develop a three-way classification of contracts to describe stages on the continuum of market relationships. This classification divides contracts into three categories; classical, neoclassical and relational based upon the uncertainty, frequency of transaction occurrence (occasional or frequent), and the degree of asset specificity in the transaction (non-specific, mixed or idiosyncratic).

[24] A firm that both makes and buys one or more of the same input characterizes tapered integration.
[25] Quasi-vertical integration is characterized by the downstream firm contracting with a supplier for the actual manufacture of input, whereas with full integration the production process itself is internalized. (Monteverde and Teece, 1982)

1. *Classical Contracts*: Classical contracts are governed by legal rules and documents defining contingencies (and applicable responses) and discourage third party involvement. In the case of frequent transactions involving non-specific investments and a selection of buyers and sellers these tend to be spot market transactions.
2. *Neoclassical Contracts*: Long term agreements where asset specificity may exist. It is typified by trilateral governance, hence, contracts will have "built in flexibility" to deal with unforeseen events and encourage third party participation like arbitration. An alternative to neoclassical contracts would be to vertically integrate to handle potential contracting problems.
3. *Relational Contracting*: This involves a specific ongoing relationship with specific assets and where the terms of the agreement change as the relationship evolves. Strategic alliances are an example of relational contracting.

   Adapted from Hobbs and Kerr (1999)

These forms of contracting are illustrated in Table 4.1.

**Table 4.1 Asset Specificity and Transaction Frequency on Governance Structure**

| | Asset Specificity | | |
|---|---|---|---|
| Frequency | Non-specific | Mixed | Idiosyncratic |
| Occasional | Classical contracting. For example, purchase or sale of standardized goods. | Neoclassical contracting. For example, sale or purchase of customized equipment. | Neoclassical contracting. For example, construction of a factory. |
| Frequent | Classical contracting. For example, purchase or sale of materials/inputs | Relational contracting. For example, purchasing of customized inputs. | Full vertical integration/Unified governance. For example, location specific transfer of intermediate products across successive stages of production. |

Source: Adapted from Williamson (1986)

### 4.1.7 Risk and Uncertainty in Vertical Coordination

Any type of contractual arrangement is a means of mitigating risk and uncertainty for agents of a business relationship. Outside the economic discipline, the terms risk and uncertainty are often used interchangeably, however, within economics these terms hold distinct and exact meanings. Risk is a distribution between known parameters and the probability of a specific outcome can be assigned a numerical value within a known distribution (Knight, 1921). Uncertainty, also entails a random component, however, it lacks distribution parameters. Thus, no numerical values can be assigned to the mean and variance of a decision under uncertainty (Knight, 1921).

Uncertainty is a problem when asset specific investments are made. For, example, the future demand for pork can be presented in terms of probability. If a group decides to make the asset specific investment to build a hog barn they can use the

numeric probability to weigh the potential returns of their investment to determine the risk. However, if this investment is in a market with only one buyer, then there is an element of uncertainty that can not be quantified. The sole buyer may, or may not, decide to act opportunistically and exact monopsony rents from the hog operation.

Given a situation where there are two parties involved in a transaction, the level of uncertainty and asset specificity affect the prevailing governance structure. When one party is planning asset specific investments, where uncertainly is high, vertical integration may result. However, if uncertainty is low, then long-term contracting may be appropriate. The ranges of governance structures given differing levels of uncertainty and asset specificity are illustrated in Table 4.2.

**Table 4.2 Relative Asset Specificity and Uncertainty for Vertical Coordination**

| | Asset Specificity | | |
|---|---|---|---|
| Uncertainty | Low for both parties | High for both parties | High for one party, low for other party |
| High | (...Depends on frequency) | Unified governance/ Vertical integration | Unified governance/Vertical integration |
| Low | Classical contracting/ Spot market governance | Bilateral governance/Relational (long-term) contracting | Unified governance/ Vertical integration |

Source: Hobbs and Kerr, 1999

## 4.2 Vertical Integration in the Electricity Industry

The electricity industry is often considered the standard example of why vertical integration takes place. Highly specific assets and frequent transactions typify the electricity industry. As was described in Chapter two, the electricity industry can be subdivided into three components: generation, transmission and distribution. These market components are sometimes referred to as being inseparable since they all involve stranded assets and depend upon frequent transactions. For example, once a coal fired thermal generation plant, a nuclear power plant or a hydroelectric dam is built they are immobile. They can not be used for processes other than generating electricity and have almost zero salvage value unless they have access to a market to sell electricity into. The means by which a generator accesses a consumer market is via high voltage transmission wires. Once the electricity has been transmitted, a distribution network converts the electricity to voltages usable by residential and commercial customers. If the transmission lines are owned by someone other than the generation company this exposes the generator to opportunism. For example, the owner of the transmission lines may refuse to maintain the lines, causing service interruptions, to negotiate a higher transmission fee. Similarly, if the transmission company has built high voltage lines to service a power plant, the plant could try to renegotiate an ex-ante contract by threatening to close down the power station.

Similarly, the frequency of transaction in the electricity industry is an important aspect contributing to vertical integration. Transactions between market components is continuous (very frequent). Hence the susceptibility to opportunism is similarly great. Referring to Table 4.1 it can be seen that the combination of

idiosyncratic asset specificity and high frequency leads to vertical integration as the optimal organizational form.

Consequently, generation and transmission are generally vertically integrated. If they are not then government regulation of the transactions between the two components is common.

### 4.3 Natural Monopoly

Another factor, which contributes to the electricity industry being vertically integrated, is that of natural monopoly. Due to the high investment costs required to connect residences with electrical wires it is impractical to have multiple sets of wires all leading to the same residences. This precludes consumers having several competitors vying for their business. The same principle applies to having several power plants within a small area all competing for the same consumer dollars.

This can be represented via an economic explanation using cost curves in Figure 4.1.

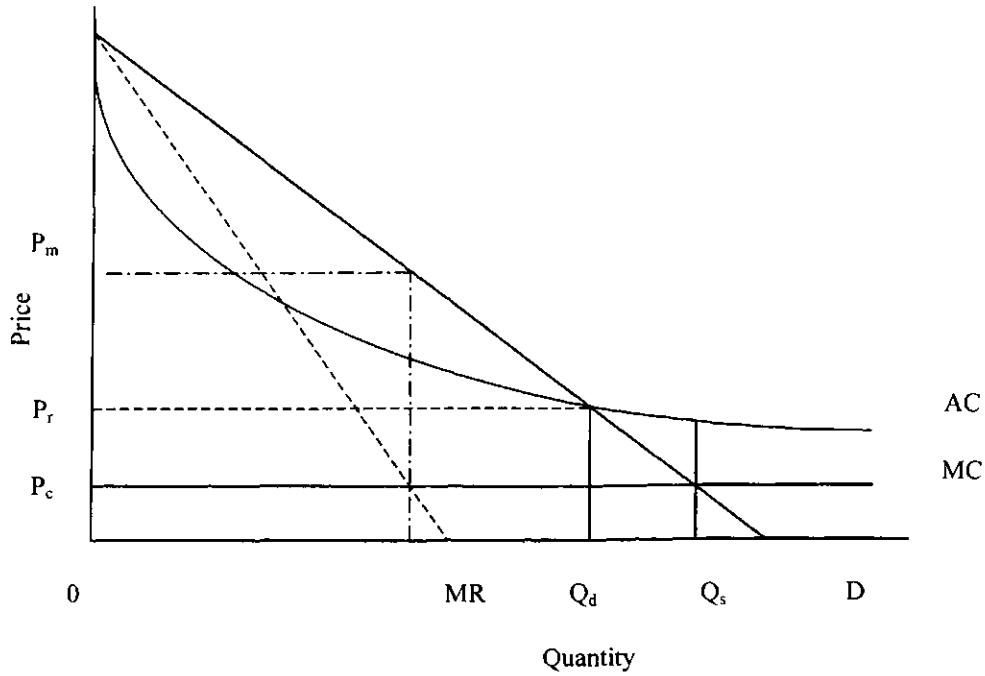



**Figure 4-1 Natural Monopoly**

The average total cost of developing an electricity system might be so high that only one firm may exist and remain profitable. Thus, for the average cost of production to equal demand for the electrical jurisdiction, the firm must be large enough that its costs can be averaged such that it equals demand. Within Figure 4.1, the initial increment of the AC curve is almost infinite at the "Price" axis. However, because the costs of maintaining the system are low, the MC curve is relatively horizontal. Although the AC is declining, it does not reach the MC curve before it is intersected by the demand curve.

If the electrical utility were to price at $P_c$ (the competitive price) where MC=D there would be a loss incurred on all sales of electricity. This would bankrupt the company. The electricity company would like to charge $P_m$ (the monopoly price) where

MR=MC. Government regulation, however, usually prevents monopoly pricing. Thus, legislation has tended to mandate electricity companies to charge $P_r$ (the regulated price) roughly where AC=D. This allows the company to earn a normal return on its investment in exchange for an obligation to serve.

## 4.4 Conclusion

This chapter has reviewed the basic terminology of New Institutional Economics. An example of how such transaction costs can lead to vertical integration within an industry was illustrated using the electricity industry. Chapter 5, will give an in-depth study of transactions costs and opportunism using case studies relating to the institutional relationships needed to facilitate biodigester development adjacent to industrial hog operations.

# Chapter 5: Opportunism and Governance Forms

## 5.0 Introduction

The purpose of this chapter is to present examples from the economic literature of how firms have attempted to deal with incentives for opportunism and to present governance structures that have been used to counter it. The chapter begins with a definition of hold-up, appropriation of quasi-rents and a basic model describing the distribution of benefits for firms coordinating their actions up or down the supply chain (Section 5. 1). Section 5.2 defines and illustrates the concept of quasi-rents. Subsequently, Section 5.3 looks at forms of opportunism. Section 5.4 presents criteria for opportunism. Section 5.5 defines asset specificity and presents examples pertaining to opportunism owing to specific assets. Section 5.6 illustrates uncertainty and monitoring costs, Section 5.7 exemplifies opportunism owning to frequency of transactions. Section 5.8 outlines the situation of uncertainty over quantity and timing, Section 5.9 looks at complexity of exchange and the various contractual mechanisms to mitigate opportunistic tendencies. Section 5.10 deals with the decision to vertically integrate and Section 5.11 examines the formation of joint ventures. Section 5.12 concludes this examination of the hold-up problem and introduces Chapter Six.

## 5.1 The Hold-Up Problem

Hold-ups are often characterized as one agent in the production chain refusing to invest due to the fear of ex post opportunistic behavior by another agent along the supply chain. For example: a typical case of the hold up problem is where Agent A has an agreement with Agent B to purchase a flow of a service from some idiosyncratic investment, which Agent B has made. The idiosyncratic nature of the investment means the value of this investment in some alternative use is much lower than it is producing the service for Agent A. The specificity of this asset also means that, once the investment is made, agent A has the ability to undervalue the output or service flow, knowing that Agent B's investment costs are sunk. Agent B, knowing that Agent A will behave in this manner, under-invests in the idiosyncratic asset (including not investing at all). As a consequence, the investment is held-up (not undertaken) even though the investment would be profitable if the appropriate transfer price for the service could be determined (Williamson, 1983).

The hold-up problem can manifest itself in more complex fashions. Such variability in the way the hold-up problem presents itself is often dependent upon the degree of asset specificity, the existence of uncertainty and the frequency of transactions. As such, firms have developed organizational forms designed specifically to minimize the opportunism that leads to hold-up. Firms have often attempted to minimize this opportunism via two possible means, either by vertical integration or by developing very detailed ex-ante contractual arrangements. In any case, a crucial

assumption is made that as assets become more specific, more appropriable quasi rents are created.

## 5.2 The Source of Hold-Up, Appropriable Quasi Rents

Appropriable quasi rents, according to Klein et al (1978), are central for evaluating a firm's responses to inter-firm production relationships characterized by asset specificity. Within this paper they explain appropriable quasi rents as: "... an asset is owned by one individual and rented to another individual. The quasi-rent value of the asset is the excess of its value over its salvage value, that is, its value in its next best use to another renter" (Klein et al, 1978:298)

Klein et al (1978) illustrates this principle by using the example of a business that rents out a printing press. Given two firms, Printer A and Publisher B, there is a contractual agreement by which B buys printing services from A at a contracted rate of $5500 per day. This is the ex-ante transaction price that will induce "A" to invest in the asset. The amortized fixed cost of the printing press is $4000 per day; it has a salvage value of $1000 (daily rental equivalent) and a daily operating cost of $1500.

The Quasi Rents for Printer A Renting out the Press to Publisher B

| | |
|---|---|
| Daily Press Rental Rate | $5,500 |
| Salvage Value | $1,000 |
| Daily Operating Cost | $1,500 |
| Quasi Rent on the Machine | $3,000 |

Hence the current quasi rent for A's printing press installed at B's location is the revenue minus the operating cost less the salvageable value. At this rental rate, Printer A is able to break even on his investment (it covers both variable and fixed costs).

However, if Publisher B becomes aware that an alternative customer of the press is willing to pay $3500 (Publisher C) then he could cut his offer for the press to $3500 after "A" has made the investment. This is enough money such that Printer A would still leave the press available for Publisher B's use since it covers daily operating costs and the salvage value. Thus, if no other renter is available to Printer A then an unscrupulous Publisher B could appropriate a $2000 quasi rent from Printer A.

The Quasi Rents for Publisher B Appropriated from Printer A

| | |
|---|---|
| Initial Daily Press Rental Rate | $5,500 |
| Re-Negotiated Daily Press Rental Rate | $3,500 |
| Quasi Rent for Publisher B | $2,000 |

Publisher B could exact rents by announcing that its newspaper business is depressed and will be unable to continue unless the rental terms are revised such that the rental rate is $3500 per day. Printer A is unlikely to refuse this plea since the offer is no worse than the offer from Publisher C and any form of legal action could effectively remove "B" from the market place, hence, further limiting "A's" market to only one renter. This would augment the small numbers[26] problem already faced by "A" and thus, increase its exposure to opportunism.

[26] The Small Numbers Problem is one in which there is a limited number of potential clients for a given firms product or services.

An alternative scenario could entail Printer A perceiving that Publisher B, due to changes in the market for its output, has embarked upon an increase in profits. To try and appropriate some of "B's" prosperity by alleging unusually high maintenance costs and (if no other press services are available) tell "B" that to maintain Press services "A" must command a price higher than the previously agreed upon $5500 per day. It would be difficult for "B" to disprove this allegation, so litigation would be difficult and could potentially drive the only realistic source of press services away. If Printer B were, for example, in the daily newspaper business then loss of press services, even for only a brief period of time, would be very costly in terms of their market. Given this threat to "B's" reputation as a reliable news service any threat by Printer A to remove its press, even if this action is in violation of a legally binding contract, would impose substantial costs on Printer B. Any intra-firm relationship entailing specialized assets hold the risk of opportunism to gain quasi rents. The solution to minimize the incentive for opportunistic appropriation is to either litigate based upon violation of a contractual agreement, or to vertically integrate, hence, transforming the inter-firm transaction into an intra-firm transaction. Both of these alternatives involve additional costs to the firm. Contractual litigation is costly not only in terms of legal and court fees but in terms of lost time since due process tends to be a lengthy endeavor. Conversely, vertical integration does internalize transactions such that any dispute would be handled "in house" rather than having to resort to the court system. However, depending on the cost and frequency of opportunism, the advantage of ownership of specialized assets entails additional internal managerial costs and these costs must be weighed against the likelihood of opportunism. According to Frank Knight:

> [T]he internal problems of the corporation, the protection of its various types of members and adherents against each other's predatory propensities, are quite as vital as the external problem of safeguarding the public interest against exploitation by the corporation as a unit.
>
> (Knight, 1921:54)

## 5.3 Forms of Opportunism

In economics, opportunism is the exacting of quasi rents or, the offloading of internal losses, onto buyers or suppliers at other levels of the vertical coordination chain. The means by which these rents are exacted, or losses offloaded, manifest themselves in two different forms. These forms can be broadly grouped as "inherent" opportunism and "circumstantial" opportunism. The difference between them depends on the accuracy with which they may be observed ex-post.

Returning to the example of Printer "A" and Publisher "B". Since "A" has made investments into specific types of equipment to service the market of "B", then "B" could exact either inherent or circumstantial opportunistic rents.

An example of inherent opportunism would be if "B", knowing that "A" did not have any alternative renters for its equipment, could insist upon a lower rental rate than was previously agreed upon. This would be backed up with the threat of "B" withdrawing from the agreement, in which case "A" would get nothing. However, one must assume that "A" has more to lose from the agreement being broken than "B". An example of circumstantial opportunism would be if "B" insists upon a reduction of the rental rate claiming that its business was not making money and the only other alternative would be to shut down. Therefore, Printer "A" is in the position where they

must decide to either lower their rental charges or face the possibility that "B" would go out of business. If "A" does not have the information to prove whether "B" is telling the truth, a risk averse printer would see lowering its rates as prudent. The outcome of either form of opportunism is the same; thus, the two forms of opportunism are differentiated upon the availability of information to printer "A". In the case of inherent opportunism, Printer "A" is aware that Publisher "B" is renegotiating the contract to extract rents. However, in the case of circumstantial opportunism, Printer "A" does not have the information to determine if Publisher "B" is actually facing bankruptcy if the rates are not lowered. Thus, if "A" chooses to not lower their rates, and "B" does go broke" then "A" will have lost an important (perhaps only) customer. Hence, circumstantial opportunism arises due to asymmetric information between "B" and "A"

This discussion has covered incentives for opportunism given appropriate circumstances. Opportunism is a characteristic of human behavior and, as such, not subject to definite patterns of manifestation. People are not mandated to behave opportunistically given the aforementioned scenarios. Nevertheless, it may be assumed that one is more likely to observe opportunistic behavior in these circumstances. This might be best summarized by paraphrasing Oliver Williamson (1971) when he asserted that not all transaction partners act opportunistically all the time but one must always be concerned about the possibility.

## 5.4 Criteria for Opportunism

As was outlined in Chapter Four, the choice of an appropriate governance structure between buyers and sellers is, in part, determined by transaction costs arising

from the possibility of opportunistic behavior. The risk of opportunism is subsequently gauged by the existence of four criteria.

These criteria are:

1. Asset specificity (in the presence of relationship specific investments).
2. Uncertainty and monitoring.
3. Frequency of transactions.
4. Complexity of exchange.

No one criterion is sufficient for opportunism to arise. However, the presence of two or more of these criteria in a business arrangement increases the likelihood of opportunistic behavior. Transaction cost economics recognizes asset specificity as the most important aspect for distinguishing relationships between buyers and sellers (Balbach, 1998).

## 5.5 Specific Assets

Oliver Williamson defines relationship specific investments (specific assets) as "durable investments that are undertaken in support of particular transactions, the opportunity cost of which investments is much lower in the best alternative uses or by alternative users should the original transaction be prematurely terminated" Williamson (1983:526).

Williamson further details specific assets by dividing them into four categories.

| | |
|---|---|
| Site specificity: | Both buyer and seller are in a "cheek-by-jowl" relation with one another, reflecting ex ante decisions to minimize inventories and transport expense. Once sited, the assets in question are highly immobile. |
| Physical asset specificity: | When one or both parties to the transaction make investments in equipment and machinery that involves design characteristics specific to the transaction and which have lower values in alternative uses. |
| Human-capital specificity: | Arising as a consequence of learning-by-doing, investment and transfer of skills (specific human capital) specific to a particular relationship. |
| Dedicated assets: | General investments that would not take place but for the prospect of selling a significant amount of product to a particular customer. If the contract were terminated prematurely, it would leave the supplier with significant excess capacity. |

As durable transaction-specific investments become more important, the transactions costs associated with mediating vertical relationships in conventional spot markets increase: " ...the argument is that transaction-specific sunk investments generate a stream of potentially appropriable quasi-rents equal to the difference between anticipated value in the use to which the investments were committed and the next best use. The presence of transaction specific investments creates incentives for one party to "hold-up" the other, ex-post, and can lead to costly haggling" (Joskow, 1985:38). The following examples highlight the type of asset specificity in question. Often examples exhibit characteristics of more than one type of asset specificity. For example, a power plant will be both site specific and be a physically specific asset. Thus, each example is chosen to illustrate a type of asset specificity and is not intended to be an exclusive representation.

### 5.5.1 Site Specificity: Mine to Mouth Electricity Generation

Mine to mouth electricity operations exhibit more than one type of asset specificity. However, site specificity factors prominently. Mine to mouth electricity generation involves an electrical generating facility adjacent to coal reserves from which coal will be mined for that plant, with effectively zero coal transportation costs. A high voltage transmission system is used to transport the power from supply point to load centers (Joskow, 1985). With just one coal source in mind, coal-fired plants are designed to optimally burn the specific coal from this mine so as to maximize thermal efficiency.

A dilemma is subsequently faced by utilities choosing to locate a generating facility adjacent to a fuel source since they open themselves to site specific opportunism if they do not own the coal source. For producing electricity, transportation represents a large part of delivered cost. Thus, utilities must decide to locate near a fuel source and transport the electricity via high voltage wires or locate near the consumer demand and transport the fuel to the plant. Given the high cost of transporting low value bulk goods, like coal, and popular demands not to have polluting industries, like coal fired electricity "in their back yards", utilities have migrated toward mine to mouth operations.

During the 1960s a utility in Florida, Tampa Electric, built a mine to mouth generating facility adjacent to an Appalachian coalfield. Tampa Electric entered into a long-term contractual relationship with the coal supplier Nashville Coal. After the power plant was completed, Nashville Coal subsequently tried to renegotiate the contract to obtain a higher price (a hold up situation) by threatening to cease supplying the power plant and diverting their coal production to another buyer (Joskow, 1991).

If Tampa Electric designed and built a power plant planning to source coal exclusively from a mine owned Nashville Coal, it could have been subject to either form of opportunism. An example of inherent opportunism would have been if, after the power plant was completed, Nashville Coal simply refused to supply coal at the previously agreed upon price and insisted on a higher price. Tampa Electric could have planned for this ex-ante and locked the coal mine into a "water tight" contract that would empower them to take legal action and sue the coal mine for losses incurred due to "arbitrary" coal price changes. Thus, inherent opportunism can be thought of as acts of opportunism given a predictable set of market conditions.

Circumstantial opportunism, on the other hand, can be thought of as opportunism based upon changes in market conditions such that it is more beneficial for the opportunistic firm to face the consequences of legal action rather than continue with the contractual agreement. Using the example of Nashville Coal and Tampa Electric, markets may change such that the price of coal triples. Even if the contract includes a price escalator clause to allow for fluctuations in the price of coal such a large change in price could be sufficiently large that Nashville Coal would be better off to terminate its relationship with Tampa Electric and face the legal consequences.

In either scenario, Tampa Electric has a site-specific asset, the generator, which has no salvage value and cannot be moved and there is the possibility of having quasi-rents exacted through opportunism.

### 5.5.2 Physical Asset Specificity: Natural Gas Pipelines

Natural gas pipelines are examples of physical asset specificity. The interface between natural gas wellheads and pipelines has been referred to as an example of a "bottle-neck" (Lyon and Hacket, 1993). Gas wells and the pipelines necessary for transporting gas to customers are highly specific assets with no alternative uses. This creates a bottleneck due to the extremely large quasi rents associated with transportation links between wellhead and customers. If the pipeline owner chooses to act on the inherent opportunism and denies a wellhead access to its pipeline, then the gas well is effectively worthless. Similarly, a more circumstantial means of opportunism may be practiced by the owner of the pipeline by claiming that the pipeline is at capacity and if the owner of the wellhead wants to transport more gas then it will be at a much higher access fee. Since assets like pipelines are physically specific, this is an understandable argument because a pipeline is built with a certain capacity in mind and any amount of gas greater than that is impossible to transport. This exemplifies the idea of "bottle-neck", as the amount of gas available may be analogous to the body of a bottle, however, its flow to market is constrained by the diameter of the neck (the pipeline). Thus, if the same owner does not control the pipeline and wellhead, there must be binding agreements to ensure consistency of service. As these were expensive and long-lived capital intensive ventures with only one use, the transportation of natural gas, pipeline financing and viability often depended upon guarantees of shipment by producers and guarantees of long term purchase by local distribution companies (Teece, 1990).

The converse effect of the wellhead acting on either inherent or circumstantial opportunism associated with the pipeline is also possible. For example, the owner of the well head may simply close down the well claiming it is no longer profitable. Alternatively, perhaps a more likely scenario might be that the gas well owners could state that due to the low price of gas they will have to shut down the well unless the pipeline company is willing to reduce its pipeline access charges. In either case, the owner of the pipeline is in a difficult position since the pipeline is physically specific (designed only to transport gas from this well and nothing else) to this gas well and has no salvage value. Hence these physically specific assets hold no alternative uses.

### 5.5.3 Dedicated Asset Specificity: Japanese Beef

In the early 1990s Japan's beef importing system was considerably liberalized. The lowering of these barriers at first seemed to provide new opportunities for beef exporting nations like Canada, the United States, Australia and New Zealand. However, the Japanese market is characterized by intricacies that make market penetration a challenge for foreign beef producers.

Historically, the Japanese diet has been based on rice, soybeans and fish with meat consumption being a relatively new phenomenon (Klein and Yoshida, 1990). The characteristics valued by Japanese consumers are quite different than those of beef consumers in the major exporting countries served by beef producers in the aforementioned exporting countries. Of particular importance are the degree and the nature of fat content. Rather than the "lean" beef demanded by consumers in the

exporting countries, the Japanese culinary style requires heavy intra-muscular fat (marbling) content (Hobbs and Kerr, 1993). To produce marbled beef, cattle must be grain fed in excess of 250 days rather than the 130 days typical in exporting countries (Kerr, Hobbs and Gillis, 1990). This additional time spent in feedlots leads to a substantial price risk for exporters due to greater production costs as well as the increased lag between production and marketing decisions. Over that period market prices in Japan could decline such that the beef cannot be profitably shipped to Japan: "an exporter is left with beef which is considered "over-fat" for the domestic market and can only be sold at a considerable price discount" (Hobbs and Kerr, 1993:49).

Also of importance is the Japanese preference for fresh rather than frozen meat (Hobbs and Kerr, 1993). This necessitates shipping and storage in which the beef is chilled rather than frozen. Chilling is a more expensive process and it significantly reduces the flexibility exporters have for bringing their product to market since it can not be stored for long periods of time if prices are low.

The nature of consumer demand creates a situation where an exporter must make investments specific to the Japanese market. These investments can be thought of as dedicated assets since they create a product exclusively for one market that has no alternative buyers.

### 5.5.4 Human Capital Asset Specificity: Fisher Body and General Motors

A benchmark example of the hold-up problem is that of General Motors' purchase of Fisher Body in 1926 (Klein et al, 1978). In this paper, the risk of hold-up is

cited as the main reason for General Motors (GM) opting, in 1926, to vertically integrate Fisher Body rather than maintain their contractual relationship until its fruition in 1929.

Benjamin Klein (2000), who further detailed General Motor's choice to vertically integrate Fisher Body added further weight to the argument. Klein asserts that: "the presence of transaction-specific investments... created a potential hold-up problem that increased market contracting costs, and, therefore provided the incentive to vertically integrate." (Klein, 2000:200) Hence, his analysis of the contractual relationship between Fisher Body and General Motors (GM) provides an example of the hold-up mechanism when dealing with multiple parties who have a vested interest in the performance of dependant specific investments.

General Motors was founded in 1908 and incorporated in 1916. From its inception, GM followed a policy of increased self-manufacturing of components and parts. Therefore, given the challenges in forming contractual agreements for the coordination of auto bodies for automobile production it is logical to question why General Motors did not vertically integrate auto-body production from the beginning? To appropriately answer this question one much take into account both the historical and the transactions cost components.

In 1919, Fisher Body entered into a long term contract in which GM would buy substantially all their output of enclosed bodies at cost plus 17.6% for a ten year period (up to 1929). General Motors was anxious to enter into this deal since autobody production had been undergoing significant developments in closed automobile body technology and Fisher Body held all the relevant firm specific human capital for the design and manufacture of such bodies (Freeland, 2000). Up to that time, most car

bodies were merely adaptations of open carriages and were designed without the special needs of automobiles taken into account (Coase, 2000). Hence, Fisher was the largest automobile body manufacturer in the industry (Pound, 1934) and supplied all the leading automobile manufacturers of the day: Cadillac, Buick, Hudson, Chalmers, Studebacker, Chandler, Cleveland, and Ford (Fisher, 1954).

In order for Fisher Body to produce closed bodied for GM, it had to make an investment in plant and equipment that was specific to GM. Hence, in the 1919 agreement, GM acquired a 60% interest in Fisher via the purchase of 300,000 of Fisher's 500,000 authorized common stock. However, despite owning the majority of the company, the agreement entailed a voting trust that ran until 1924 giving the Fisher brothers (original owners of Fisher body) control of the company (Klein, 2000).

The subsequent question remains as to why didn't GM simply hire members of the Fisher Body team? This is because human specific capital is usually not possessed by a single individual but by a team of employees (Klein, 2000). This would be particularly important during the time period in question since automotive technology was developing rapidly and the pool of individuals with specialized knowledge would have been small. Thus, the skills for producing auto bodies:

> ... was shared by a collectivity of Fisher employees and had become embedded in the firm as a whole. By transferring ownership of the team's labor contract to a central owner [GM], vertical integration made it much less likely that the Fishers could utilize their specialized knowledge and skills against GM. (Freeland,2000:38)

Since Fisher Body made GM specific investments, the automobile bodies produced from these investments would be incompatible (hence worthless) to any

alternative auto manufacturer. This would have allowed GM to enter into quasi-rent seeking opportunistic behavior. General Motors could have threatened to either reduce demand for Fisher produced bodies or terminated the contract unless Fisher lowered its prices to the level just above Fishers shut down point. If GM ever made these threats, they would have certainly faced a legal battle. However, this battle would have been expensive and the reward, perhaps, little more than a moral victory

The long-term (10 year) exclusive agreement effectively gave Fisher Body a 10-year monopoly over the supply of auto-bodies to GM. This set the stage for potential hold-up by Fisher. If Fisher Body had claimed that they would have no choice but to decrease auto-body supply unless GM agreed to pay more, then the only possible recourse for GM would have been to initiate a lengthy court process to dispute Fisher's claims or, risk legal action from Fisher if GM tried to source its auto-bodies from another supplier.

To avoid these possible situations the contract included a formula where the price was set equal:

> Fishers' "variable cost" plus 17.6 percent. The 17.6 percent up-charge presumably was designed to cover Fisher's anticipated capital and overhead costs. In addition the contract further protected GM with a most favored-purchaser clause... this term guaranteed only that GM would not pay more than other buyers of like products. (Klein, 2000:202)

Although the contractual arrangement between Fisher Body and General Motors had mechanisms for contingencies, it was these very mechanisms which contributed to the breakdown of the agreement.

From 1919 to 1924 the agreement, although imperfect, was effective for both parties. However, during the 1925-26 production year the demand by GM for closed Fisher bodies increased dramatically. At that time, Fisher's main plant for Buick bodies was located in Flint. General Motors, on the other hand, had their Buick plant in Detroit. According to the agreement GM had to pay the shipping costs to transport the auto-bodies from Detroit to Flint plus the 17.6 % which Fisher contractually charged for labor costs to handle the bodies. General Motors was thus anxious for Fisher to build a plant adjacent to the GM Buick plant in Detroit. Additional output from GM could have benefited Fisher since it would have represented an increase in demand for their closed bodies. However, Fisher had their reservations about building adjacent to GM since that would entail further GM specific investment and, at the time, Fisher was still supplying other manufacturers and did not with to risk losing the rest of their customer base.

Even though it may have been beneficial to both parties for Fisher to build an auto-body plant in Flint, they were reticent. Thus, Fisher, via the fact that GM was exclusively tied to Fisher for the remaining four years of their contract, was imposing costs on GM in the form of added transportation and labor costs. This offered a contractual disincentive for Fisher to invest.

Although Fisher certainly did not want GM to fail, "Fisher had to look out for Fisher." The Fishers were afraid of limiting themselves to one customer so they chose to maximize their profits within the existing contract. It is unlikely that Fisher's behavior could be construed as blatant opportunism, however, they were appropriating quasi-rents by their interpretation of a formalized contract planned for certain market contingencies. Unfortunately, planning for contingencies entails contractual rigidity and

it was this rigidity which Fisher leveraged to maximize their profits. Hence, reneging (blatant opportunism) provides too narrow a view of the hold-up problem. Contracts are negotiated with the best available information in mind. However, uncertainty ensures more possible outcomes than contingencies may detail. This can be taken so far as to say that it is the attempt to entrench all future contingencies which in fact may set the stage for future hold-ups (the bounded rationality problem).

In May 1926 GM acquired the remaining Fisher Body stock that it did not already own. In effect, Fisher Body Cooperation was dissolved as an independent entity and full absorbed into GM. The 1919 contact had its benefits but those were ultimately outweighed by the costs. It was these contractual "rigidity costs" which were to be avoided via vertical integration.

During the period between 1910 and 1930 General Motors, like other auto manufacturers, was intent on having access to the executive talents of the Fisher Brothers since "their experience in auto body manufacturing and their reputation for body styling were important features for GM… The problem of identifying talented managers was especially acute for GM" (Casadesus-Masanell and Spulber, 2000:96).

For GM, the most important characteristic of their acquisition of Fisher Body was the shift in operating control from the Fisher brothers to GM. Naturally, there was a shift in control over physical capital. However, GM could have provided the necessary capital and started to make their own auto-bodies. However, by vertically integrating, GM gained the experiential synergies present in the existing team of people skilled at the design and manufacture of auto-bodies. The expertise in the area of auto-body manufacture was then combined more effectively with the other aspects of vehicle

manufacturing. In the late 1920s choice of body style (for both structural and marketing standpoints) became more important, the gains from coordination between chassis and body increased substantially.

## 5.6 Uncertainty and Monitoring Costs

It is often cited that for production using a specialized input, firms must determine if it is more expensive to acquire an input in the market than to self provide. A key element in determining this cost is the determination of the value of the intermediate good. Barzel (1982) argued that the attributes of a good must be measured to judge the value of that good. The cost of measuring these attributes may result in wealth transfers. In addition, if some variability exists in desirable attributes of the intermediate product, it may require costly sorting to determine its value (Barzel, 1982).

The beet sugar industry in the United States exemplifies the issue of uncertainty over quality, output quantity and what institutional frameworks have been used for monitoring. Balbach (1998) asserts:

> In the sugar beet industry, the relationship between growers and the processors is key. Contracts have always been used to govern the exchange of sugar beets from the grower to the processor. Contracts are used due to the nature of sugar beets. Sugar beets are perishable and expensive to transport. Thus, processors use contracts to ensure an adequate supply for their factories. There are no other buyers of sugar beets than sugar processors, so growers need contracts to ensure a market for their crop before it is planted. (p158)

The perishability of sugar beets renders beet producers open to opportunism. This opportunism could be of an inherent form. For example, if the beet buyer refused

to pay the seller a previously agreed price at delivery, the seller would have little choice but to accept that price, or, dump the beets. However, circumstantial opportunism could take place if the processor were to claim that the plant had enough beets at this point in time and the sellers could either wait until the beets were needed or accept a lower price: "after being harvested, beets burn sugar to stay alive" (Balbach, 1998:169). Thus, the longer the grower must wait, the lower the quality, hence value, of the beets. The grower has no means of monitoring the workings of the sugar processor "behind closed doors" to determine if the processor is actually unable to take the beets at this point in time or is merely acting opportunistically.

For both processor and producer the issue of beet quality, in terms of extractable sugar, represents a monitoring problem. This is because to accurately judge the value of a good, its attributes must be measured. The cost of measuring the attributes, which determine extractable sugar, may be expensive and mistakes in measurement may result in inefficient benefit transfers (Barzel, 1982).

Sugar beets are an intermediate good in the production of sugar. This means that rather than being the product that consumers purchase, sugar beets must be further processed before they reach the market. Typically, the assets required at both the production and the processing stages are highly specific and interdependent. Such specificity can lead to opportunistic rent seeking. The means by which the industry has organized itself to limit opportunism is via contracting or vertical integration of the stages of production and processing.

Balbach (1998) asserts that two types of vertical coordination (governance structures) typify the sugar beet industry:

- One type is investor-owned processors who purchase sugar from beet growers based upon percent-sugar contracts
- The other type is vertically integrated grower owned cooperatives that use extractable sugar contracts

The fundamental difference between these two forms of governance structure is the relationship between the growers and the processors. Investor owned beet processors use contracts to purchase beets. The contracts use a system of "percent-sugar-content" in which producers are paid based upon the weight of the beets delivered. Under these contracts a grower is paid on the basis of the tonnage of beets delivered. The processor assumes that the beets have a fixed quantity of sugar per ton. This imparts an incentive structure for the producer that emphasizes the production of the maximum amount of beets regardless of quality where quality represents the presence of impurities in the beets. The level of impurities affects the extraction rate, hence cost, of refining sugar. Beet growers thus use agronomic practices, such as heavy fertilizer use, which have a positive affect on gross yield of beets yet increase the level of impurities in beets.

Rewarding farmers for their extractable sugar content would seem to offer an effective solution to improving the quality of the beets they supply, logistical problems over information collection responsibility render a more accurate measurement nearly impossible. Thus, processors have an incentive to underreport quality and keep returns for themselves; producers are not able to trust the processor accuracy in reporting sugar content.

The producer owned, vertically integrated, cooperative sugar processors resolved the issue of increasing sugar beet purity by creating a positive feedback mechanism that rewarded farmers for producing higher quality beets. This mechanism entailed extractable sugar contracts in which the processor measured the amount of sugar recovered from each producer's beets and compensating them accordingly. These contracts have led to the cooperative processors being supplied receiving beets with 12% more sugar per ton of beets than for the investor owned processors

Such a positive feedback system requires monitoring of the beets received. Due to the incentive for investor owned processors to underreport sugar content a mutually acceptable monitoring system would be necessary for investor owned processors to achieve extractable sugar contracts. According to Balbach (1998), the cost of mutually acceptable monitoring of quality measurements is too high for investor-owned firms to make extractable sugar contracts.

## 5.7 Frequency

Incentives for opportunistic behavior may occur because transactions are either a continuous stream of transactions (very frequent) or occur only once (very infrequent). When transactions occur only once neither the buyer nor the seller have the incentive for "repeat business." Therefore, either agent may act opportunistically in this situation if the benefits of opportunism are perceived to be greater than any recourse (i.e. litigation).

Opportunism may also arise when transactions are very frequent. This is because the agents involved may make their business dependent upon a continuous flow (frequent transaction) of an intermediate good and a threat to disrupt this flow could be a

means to exact opportunistic rents. This can apply to either the buyer or the seller. An example is the transaction between electrical utilities and electricity co-generation IPPs. Co-generators are companies separate from the utilities, which generate electricity as a co-product of their other production activities. In designing contracts for purchasing electricity from the co-generator, the utility must offer incentives such that the co-generator will be willing to make the initial investment in the generating facilities. Therefore, since the construction of a co-generation facility requires a large-scale investment dedicated to a single customer, the utility, before the co-generating company begins construction it requires the utility to commit to the purchase of the electricity.

The electricity industry tends to be typified by a single utility holding a monopoly over a given area for the provision of electricity. The market has no competitors and governments legislate "obligations to serve" since consumers have no alternative suppliers. Since retail consumers must buy their electricity from the regulated monopoly supplier: "these franchised monopolies have a legal obligation to supply and to plan for the needs of all retail customers within their franchise areas and to make electricity available at prices approved by state regulatory commissions" (Joskow, 1997:121). The obligation to serve tends to specify the number of supply inconstancies a utility may have over a given period of time. This might entail a customer facing no more than one power outage per given time period. If the utility exceeds that number of outages, then the consumer has a claim for damages.

When a utility decides to source its generating capacity from external agents, like co-generators, outside its management sphere the utility must ensure that the supply is not so inconsistent as to interfere with their obligation to serve. This is because the

obligation to serve necessitates a frequency of service to customers. Therefore, the utility must have similar frequency of supply from its IPP partners if it is to meet its obligations to serve or it must retain offsetting capacity itself.

Since utilities are legally bound to provide continuous services to their customers, the transactions that take place between utilities and their suppliers (IPPs) must be similarly continuous. This creates a situation where either party could act on either inherent or circumstantial opportunism to capture quasi-rents. Inherent opportunism could be practiced by either the utility, via refusal to buy electricity after the IPP has made investments in generating capacity, or by the IPP via closing down their plant and refusing to supply electricity.

An example of circumstantial opportunism would be if the co-generating IPP claimed that it would reduce its electrical generating capacity since the market for its main product is depressed. If the utility lacks the redundant capacity within its system to make up for the loss of this IPP's capacity, then the utility is in a poor bargaining position. Thus, the IPP might suggest that if the utility wants the IPP to maintain its level of electrical output, then they would have to receive more money to make it financially viable.

Utilities who source electricity from IPPs can maintain their obligation to serve in one of two ways. Either the utility must maintain enough redundant capacity such that they can maintain the obligation to serve even without the supply of electricity from the outside source. The other is to contractually mandate the utility via a penalty structure if it does not supply electricity when the utility demands. However, these penalties must

not be so great that the co-generators would be unwilling to invest in the generating facility.

Due to the frequent nature of transactions in the electricity industry, the threat of service irregularities is a source of opportunism. From the standpoint of a utility contracting electricity from an IPP, the threat of service irregularities can be managed by either owning redundant generating capacity or, ensuring an appropriate incentive structure to reward (or penalize) IPPs for the regularity of their service.

### 5.7.1 Quantity Uncertainty and Timing

Petroleum coking operations exemplify contractual arrangements to limit opportunism from uncertainty over timing and quantity. Petroleum coking is a process that takes the heavy residual oils left over from the initial distillation of crude oil. Coke represents 15% of the volume of oil but it accounts for less than 3% of the value. If not coked, the residual oil would be processed into heavy fuel oil or turned into asphalt (Goldberg and Erickson, 1987). As the revenue potential from alternative uses for petroleum coke are limited it can be thought of as a residual product of petroleum production.

Roughly 60% of coking coal is used as fuel in utility boilers and cement kilns while the other 40% is converted to pure carbon in a process called calcination for use in the production of anodes for the electrolytic cell reduction of alumna to aluminum (Goldberg and Erickson, 1987). About 3% of the production cost of aluminum can be attributed to coke (Goldberg and Erickson, 1987).

Although coking coal represents only a small portion of the cost of aluminum it is an important input. Since transportation and storage can consume a large portion of potential revenue from the production of coke it is optimal to locate coking facilities as close as possible to its demand (i.e. calcinators).

> Because coke is a low-value, bulky product, transportation costs play a significant role in the economics of coking... the bulkiness of coke makes it expensive to store. Coke is also a fire hazard and a source of pollution unless it is put in covered storage. (Goldberg and Erickson, 1987:374)

Conceivably, a coker could locate close to a port such that the material could be transported by barge to a variety of customers but, due to the high cost of land close to ports there would not be a space available for coke storage and "the opportunity cost of land depends crucially on where the coke is stored" (Goldberg and Erickson, 1987:375).

Given the asset specific nature of coking coal there has been, understandably, some vertical integration in the industry. Thus, there has been a substantial amount of backward integration into calcinating by aluminum companies; however, there has been very little forward integration by refiners (Goldberg and Erickson, 1987).

However, contracting is common for this industry. This may be reasoned because "the parties involved want to assure continuation of their relation while still maintaining enough flexibility to adapt the relation to changed circumstances" (Goldberg and Erickson, 1987: 375). Thus, maintaining contractual arrangements rather than vertically integrating may be a means of spreading risk amongst different economic entities and to spread the risk over contractually coordinated, yet separate, entities. Within such agreements parties to a long-term contract have a mutual interest in

designing a contract that maximizes its value to both parties and much of the structure of contracts reflects the attempts of parties to constrain their "non-cooperative behavior in order to increase the total pie.... But it should be understood that the opportunism problem is omnipresent" (Goldberg and Erickson, 1987:375).

Given the dedicated nature of such assets, contracting parties for petroleum coke can face short-run coordination problems. For example, the coker's costs depend on the rate at which coke is removed from the refinery and if it is removed too slowly then the coker will face expensive storage costs. Thus, both buyers and sellers of coke rely upon a continuous stream of transactions. However, there is the possibility of a buyer trying to offset its costs by refusing to accept coke shipments. This may be an example of inherent opportunism to try to renegotiate the price of coke because the coker would have to either accelerate the search for new customers, reduce the selling price, add to inventory if storage space is available, reduce the production rate, or even shut down its coking operation. Since many cokers are divisions of petroleum firms, none of these options would likely bankrupt the company but they are all wasteful uses of expensive assets. Such actions on the part of the buyer could also be a means of circumstantial opportunism by, for example, arguing that the demand for aluminum is low so the coker will have to assume a greater portion of the coke storage costs.

The coker could similarly exact opportunistic rents from the buyer if delivery of the coke deviates from the optimal rate. If the coker sends too much coke, then the buyer would have to find storage to accommodate it. On the other hand, if too little coke is supplied then alternative suppliers must be found or production must be limited. In either case, opportunism could be manifest in inherent or circumstantial form.

Contracts between buyers and sellers of petroleum coke include "take or pay clauses" to mitigate incentives for inherent or circumstantial opportunism. Take or pay clauses require that the purchaser pay for a contractually specified minimum quantity of output even if delivery is not taken. For example:

> Alcoa's contract involving Gulf's new coker gave Gulf the right to shut down the coker if inventory at the refinery reached 10,000 tons (twenty days output). Alcoa would have to pay a "standby" charge during the shutdown period of $75,000 per month. With the contract price at $12 (before escalation) and the contract quantity 500 tons per day, Alcoa in effect paid for about 40 percent of the coke, whether or not they took any... Thus, Gulf was assured that Alcoa would have to take its interests into account when determining how much coke to take. (Goldberg and Erickson, 1987: 380)

## 5.8 Complexity of Exchange: Contracts, Joint Ventures and Vertical Integration

To manage opportunistic attempts to capture quasi rents, firms utilize contracts, joint ventures or vertically integrate. For the purposes of this thesis a joint venture will be treated as a form of complex contract in which parties to the venture have a claim on the residual depending upon their respective proportion of the total investment.

A rough categorization of contractual forms to compare their relative complexities is illustrated in the following chart.

| Complexity | Contract Type |
|---|---|
| Least Complex | Market Price |
| | Fixed Price |
| | Cost Plus Profit |
| | Indexed |
| Most Complex | Joint Venture |

Vertical integration internalizes the transactions covered by the above list of contracts. However, this does not remove the costs of transacting. Rather, it makes the costs part of the firm's internal management. The costs and benefits of contracting versus vertical integration are dealt with later in this chapter.

### 5.8.1 Contracts

Much economic activity takes place within the framework of complex contracts. However, by there very nature contracts are incomplete[27]. It is impossible for all future contingencies to be planned for. Thus, contracts must remain flexible to future market changes for input prices, output prices, labor rules, government regulations, or simple changes in demand or supply. Hence, establishing a pricing formula to govern the allocation of risk and benefits for contracts lasting many years, as well as providing incentives to both buyers and sellers to perform as promised, is a difficult task. Such arrangements, optimally, should be structured to eliminate the incentives for either party to behave opportunistically; yet, pricing provisions should also be structured such that both the buyer and seller make efficient supply and demand decisions (Joskow, 1985).

### 5.8.2 Contractual Management of Price, Delivery, Quantity and Quality

Buyers and sellers use contracts to manage uncertainty over price, time of delivery, quantity and quality of goods. These issues are of particular concern given business relationships characterized by specific assets. Industries that depend on

intermediate goods in their production process often face high transaction costs, like those arising in a shutdown, if their supply or demand for intermediate goods is threatened with disruption. Thus, elaborate contracting methods have evolved to mitigate such uncertainty.

Price uncertainty depends on the nature of the good in question. As a result, four contract types have evolved to manage different types of goods: market price contracts, fixed price contracts, cost plus profit contracts and indexed contracts.

### 5.8.3 Types of Price Contracts

The following description of contracts is an adaptation of work by Joskow (1985).

| | |
|---|---|
| Market price contracts: | If the product under consideration is a homogeneous product sold in a competitive market with a clear market price, then the simplest way to determine prices is to base them on an appropriate market indicator. Given the presence of any combination of the four TCE opportunism criteria, this is not an appropriate contracting mechanism. |

Market price contracts are applicable to commodity goods that are necessarily homogeneous with an externally determined price arrived at by the interaction of many buyers and sellers. This is not applicable to long term contracts and would likely be used only in cases of individual purchases. Given these criteria, the transaction costs for such contracts would be sufficient such that the market would approach the neoclassical ideal.

[27] Incomplete contracts may be either intentionally or unintentionally so.

If the buyer in question were purchasing a heterogeneous good, then the firm would have to incur costs such as:

- Information / search costs to compare offers from various suppliers and buyers and to determine the quality of product in each offer. Subsequently, negotiating costs would have to be incurred to determine price, quality and quantity of product.
- Once product quality and quantity have been contractually specified, they must be monitored to ensure the terms of the agreement are met.
- If contractual terms are not met, then firms must incur enforcement costs, like those associated with litigation, to obtain redress.

| | |
|---|---|
| Fixed price contracts: | A price for an intermediary product is fixed ex-ante by the contract. This has poor incentive properties with regard to continuing performance since market conditions could change such that the previously agreed upon price would be much higher or lower than what is acceptable for either contracting party. |

Such contracts allow for a paradigm other than that where there is an infinite number of buyers and sellers who can be spontaneously and costlessly accessed without uncertainty. Thus, both agents have an incentive to "lock in" to an agreement with a specific buyer or seller. Nevertheless, costs must still be incurred to search for an appropriate business partner and, once a business partner is found an appropriate price (the "fixed" price) is subsequently negotiated. This price implies that the present discounted value (PDV) of expected revenues for the buyer is greater than or equal to the PDV of expected costs for the supplier.

Nevertheless, after a price has been "fixed," market conditions may change such that the price is unacceptable for either the buyer or the seller. This situation would bring great pressure to negotiate a new price via the threat of non-compliance with supply or purchase criteria in the contract. Given such non-compliance, enforcement costs such as a lengthy court action, would be necessary.

Cost plus profit contracts: The supplier is compensated for all the costs incurred in production including the cost of capital. In such an agreement, monitoring would be difficult but of vital importance. If a buyer agrees to pay a fixed percentage of a supplier's labor or capital then, to protect the buyers interests, those aspects of the suppliers operations must be open to the buyer's scrutiny.

Due to the greater complexity of the agreement, search and negotiating costs would likely be higher for such contracts than for either market or fixed price contracts. Cost plus profit contracts endogenize price changes that resolve the issue of unexpected market changes. It ensures that prices are sufficiently high that the supplier does not have an incentive to walk away from a supply arrangement when costs change due to input price changes. This mitigates the risk of the supplier leaving the contract, however, a large portion of the risk is shifted to the buyer because the seller has little incentive to minimize costs or maximize efficiencies for processes paid for by the buyer. If the seller has poor incentives to minimize costs, the buyer may become, over time, increasingly frustrated with this inefficiency. If the buyer's perception of what is efficient differs greatly from what the supplier is eventually providing, there may be enough incentive to break the agreement.

| | |
|---|---|
| Indexed contracts: | Input prices, costs of government regulations, changes in labor rules etc. can be set as a base price that is adjusted over time as input prices rise. Hence, the base price can be broken into components (labor, materials, supplies, depreciation, profit, taxes, etc.) Then each component escalated according to input price and productivity indexes. |

Indexed contracts may be seen as the most "equitable" means of structuring contracting arrangements since they do not place the burden of market uncertainty solely on one agent. However, it is unlikely that such a contract would be developed for an industry characterized by "inherent" neoclassical market prices. If this were the case then there would be no need for a contract, indexed or otherwise. Hence, indexed contracts would likely entail high ex-ante search costs to negotiate an agreement both parties find adequate.

There would also be significant enforcement costs since indexing systems, given the lack of inherent market prices, may be inadequate during periods of high inflation. In such situations, prices of the various components could diverge greatly from one another. This should make any form of dispute resolution and enforcement particularly complex (expensive) since the seller would have an incentive to invest disproportionately in those inputs that have a higher rate of indexation. This may not conform to what the buyer considers efficient business practices.

Given the complexity and high costs associated with indexed contracts, firms may decide that the transaction cost minimizing decision is to vertically integrate.

### 5.8.4 Quality Contracts

Uncertainty over quality can be the source of disputes between buyers and sellers. Buyers are always cognizant of the quality of the products they are purchasing and establish incentive mechanisms to monitor the quality of goods that sellers deliver. From the seller's standpoint, such monitoring schemes can be used as a means for buyers to practice opportunism. If it is the buyer who is responsible for grading the product and sellers have no means of verifying the grade, then sellers will be suspicious that they may have been graded unfairly.

For example, tomato production in California has several characteristics relating to asset specificity. Assets for both production and processing of tomatoes are specialized and can not be easily employed in other uses. Tomatoes, when ripe, have a narrow time range to be processed. This is often used as a text book example of opportunism. A tomato grower and a processor have agreed upon a price for the tomatoes. However, when the grower delivers a truckload of tomatoes to a processing plant, the processor can refuse to accept the shipment unless it pays a lower price. The tomato producer is in an awkward position since the expenses of harvesting and shipping have already been incurred so it may be better to accept the lower price than face the additional costs of spoilage and finding a new buyer.

Conversely, if the buyer is desperate for tomatoes then the seller may be able to extract rents from the processor. This could be backed up by the threat to dump the tomatoes or take them to another processor if there is one in the vicinity. The latter is

an example of inherent opportunism on the part of the buyer, but opportunism could present itself in a more circumstantial manner.

There could be attempts to resolve the issue of opportunism on the part of the processor by making purchase contracts with the grower for payment before the tomatoes are processed. However, if payment for tomatoes takes place before the tomatoes are processed the buyer may find that they are of lower quality than was perceived at time of delivery. This may be due to unscrupulous behavior on the part of the grower by strategically delivering tomatoes such that only high quality tomatoes were visible and were disguising the mediocre tomatoes in the load. For example, the producer could have a layer of good tomatoes on the top of the load where they can be easily accessible and graded while the lower layers of the load could be lower quality tomatoes.

Circumstantial opportunism would likely involve the issue of the inability to find a means to monitor the amount that is mutually acceptable for both buyers and sellers. The full value of the tomatoes may not be known until a sample of the full load has been taken. This would likely require specialized equipment that may be owned by either the processor or the producer. However, either side has an incentive to report findings, which are in favor of themselves. Thus, a third party is required to resolve issues over quality of the product.

To resolve the issue of monitoring and quality control for tomatoes, California has the Processing Tomato Advisory Board (PTAB), which: "measures quality for the processing tomato industry; it's a "third-party" jointly administered by growers and processors via a federal (I believe) marketing order" (Hueth, 2000). This organization

(PTAB) resolves the issue of quality and price determination by a system where all tomatoes are graded by grading stations in the state of California. These grades are then used explicitly to determine the payment made to the grower (Ligon, 2000). Thus, to limit incentives for opportunism the tomato industry formed a mutually acceptable grading agency whose standards are respected by both buyers and sellers.

## 5.9 The Decision to Vertically Integrate

The technological interdependence argument is both the most familiar and the most straightforward explanation for vertical integration. Williamson (1971) has defined technological interdependence as:

> successive processes which, naturally, follow immediately in time and place dictate certain efficient manufacturing configurations; these in-turn, are believed to have common ownership implications. Such technical complementarily is probably more important in flow process operations (chemicals, metals etc.) than in separable component manufacture.
>
> Williamson (1971 :120)

When transaction specific investments are important, governance structures will emerge ex ante to reduce the incentives either party has to exploit them ex post. Given specific assets, market uncertainty, frequency of transactions, and exchange complexity, vertical integration often maximizes benefits arising from the transaction.

The complexity of exchange is important in determining the organizational form. Firms must choose the transaction cost mechanism for limiting the incentive for opportunism. Within this thesis, there have been many examples of business scenarios

involving highly specialized assets and a limited tolerance for uncertainty. Vertical integration has been the cost minimizing choice in many of the examples in this thesis.

The decision to vertically integrate involves challenges that must be weighed against potential benefits:

> vertical integration brings numerous management challenges and significant financial demands. Contracting offers flexibility in control and risk sharing between contracting parties. However, contract coordination of inherently variable agricultural production is especially complex when numerous diverse entities are involved.
> Barry et al (1992:1219)

Holmström and Roberts (1998) examine the decision to vertically integrate or to use contractual agreements. The central question posed in this paper is "Why do Firms Exist?" What they suggest is that firm boundaries are established specifically to avoid hold-up.

> There is no doubt that the hold-up problems are of central concern to business people. In negotiating joint venture agreements, venture capital contracts, or any of a number of other business deals, much time is spent on building in protections against hold-ups.
> (Holmström and Roberts, 1998:80)

To explain the allocation of benefits to an asset specific relationship Holmström and Roberts use the following model:

$$V = V_A + V_B \tag{5.1}$$

Where:

$V$ = the capitalization of cooperation

$V_A$ = value to party A

$V_B$ = value to party B

In this relationship the benefit, V, can be only realized by the cooperation of A and B. Individual benefits to this relationship ($V_A$, $V_B$) are not necessarily equal ($V_A \neq V_B$), thus, there are different incentives to invest. Consequently, there is a trade off, since ownership shares cannot add up to more than 100%, one can only strengthen the incentives of one party by giving that party control over more assets, but, this is only possible at the expense of weakening the incentives of the other party.

Holmström and Roberts make several conclusions from the above model. For example, greater investment by party B, for generating surplus V, should correspond to more assets relative to investments by party A. This is so as to make $V_B$ more sensitive to B's investments. Conversely, if an asset has no influence on B's investment, it should be owned by A. According to Holmström and Roberts (1998): no outsider should ever own an asset that would waste "bargaining chips" that are precious for incentive provision. For the same reason, joint ownership, meaning both parties have the right to veto the use of an asset is never optimal. As a consequence assets that are useless unless used together should never be separately owned (Holmström and Roberts 1998).

Transaction cost arguments involving highly specific assets often suggest vertical integration as the optimal organizational form. However, vertical integration holds its own set of transactions costs and these are weighed against contractual organizational forms when firms are determining their boundaries. Coase (1937) asserted this concept succinctly by stating "a firm will tend to expand until the cost of organizing an extra transaction within the firm become equal to the cost of carrying out the same transaction by means of an exchange on the open market or the costs of organizing in another firm" (Coase 1937). Coase emphasizes this further by dividing this assertion into two broad sources of costs due to inefficiency.

- As a firm gets larger, there may be decreasing returns to the entrepreneurial function, that is, the costs of organizing additional transactions within the firm may rise. Naturally, a point must be reached where the cost of organizing an extra transaction within the firm are equal to the costs involved in carrying out the transaction in the open market, or, to the costs of organizing by another entrepreneur (Coase 1937).
- As the transactions that are organized increase, the entrepreneur fails to place the factors of production in the uses where their value is greatest, that is, to make the best use of the factors of production. Bounded rationality, hence, is found within the firm (Coase 1937).

The inefficiencies associated with vertical integration can be grouped into three major categories (1) bureaucratic costs (2) strategic costs and (3) production costs (Mahoney, 1992). These are discussed later in this chapter.

### 5.9.1 Internalized Opportunism

Shifting a transaction from the market to the firm is significant not because the exchange is eliminated but rather because the incentives of the parties are transformed. This may manifest as internal opportunism via sub-goal pursuit by groups of employees in the firm. Such sub-goals are efforts to manipulate the system to promote the individual and collective interests of affected managers. Williamson (1975) illustrates this as follows:

> Such efforts generally involve distorting communications in a strategic manner. Sometimes this may be done by individual mangers without the support of others. More often, however, internal distortions are due to the cooperative efforts of two or more managers. (The internal reciprocity phenomenon is a specific manifestation of such collaborative distortion). (Williamson, 1975:23)

Internalized opportunism can be thought of as strategic behavior on the part of the employees. Additional hierarchical layers may eliminate the problem of asymmetric information between contractual parties. However, as the gap between stockholders, upper management and production increases, vertical integration may result in breakdowns in the transmission of information between the various layers of accountability. Such breakdowns can be intentional so as to protect what would otherwise be thought of as inefficient activities of the firm. Problems of stockholder control typically become more severe as firms grow in size and complexity. Larger size is associated with greater opportunities for discretion (Williamson, 1975).

Such opportunism may manifest itself in the form of communication distortion (inadvertent or intentional) by employees. Although incentives may be harmonized by

internalization, members of the organization may seek to promote goals by diverting the communication system to their own uses. For example, subordinates may tell their supervisor what he wants to hear; or conversely, they report only those things they want him to know. Distortion to please the receiver is especially likely where the recipient has access to extensive rewards and sanctions in his relations within the administrative hierarchy. The cumulative effects across successive hierarchical levels of these and related adjustments to the data easily result in gross image distortions (Williamson, 1975).

### 5.9.2 Internal Procurement Bias

Once a firm has made specialized investments to internalize supply there are incentives to distort procurement decisions in favor of in-house supply. This can result in diseconomies of scale for production of that input. This can create both psychological and competitive barriers to entry (Mahoney, 1992). Hence, sub-goals of a group or bureaucratic body are easily given greater weight in relation to objective profitability considerations i.e. " I buy from your division, you support my project proposal or job promotions etc." This may in turn lead to an internal expansion bias as larger size is favored by the positive association of both pecuniary and non-pecuniary rewards with greater size amongst the functional parts of the enterprise (Williamson, 1975). There is a tendency for staff to "promote" themselves by adding additional subordinate staff to their part of the organization. Thus, the sunk costs in programs and facilities insulate these projects from displacement even if alternatives exist (Williamson, 1975). Psychologically, managers may feel commitment to cross

subsidize ailing parts of the firm. Shifting the incremental transaction from the market to the firm generally results in greater budget based support (Williamson, 1975). Competitive barriers may have arisen as a result of the elimination of competition for suppliers due to the firm producing chronic excess supplies.

Increasing firm size leads to taller hierarchies "in which managers have less contact with stock holders and personnel in lower levels... large size and hierarchical structure promote impersonal relationships within the firm" (Teece, 1976:20). Such additional complexity gives rise to finite spans of control (bounded rationality).

Additional complexity also means that there is less accountability of subordinates to superiors. This entails the "offloading" of work from one employee. This may, in fact, manifest itself into an internal expansion bias where management is driven by the belief in a reward system correlated with firm size. Succinctly, managers promote themselves by creating additional organization layers below them. Arguments in favor of internal procurement to limit the chance of opportunism from outside sources can often be used to support such additional hierarchical layers. However, rather than limiting outside opportunism, vertical integration may merely internalize it such that employees are exacting opportunistic rents. This is a cyclical process since increased managerial complexity makes it more difficult for upper managerial levels to detect such behavior. Hence, this creates another incentive to augment managerial complexity to camouflage such internal opportunism.

When a firm decides to vertically integrate it will become involved in new manufacturing or marketing tasks. For example, if an electrical generator (utility) decides to vertically integrate a coal source, it must assume an additional layer of

managerial skills and coordinate them within the existing firm structure. At some point this may reduce efficiency since, "by reason of bounded rationality, there is a finite span of control that a manager can handle." (Teece, 1976:20). The skills required for this new managerial layer could be acquired by either training current staff or hiring additional managers from outside the firm. This can be thought of as creating an additional layer of the firm's bureaucratic hierarchy. Creating this new layer necessitates the training of staff via investments of time and an opportunity cost since both the monetary and time investment could be dedicated elsewhere. Acquiring new staff involves the internal stress of and cost of training people in the corporate culture of their new employer.

Production costs are critical when a firm is in the make-or-buy decision. A vertically integrated firm that "does not utilize a sufficient amount of the input to achieve minimum efficient scale will be at a cost disadvantage against firms that contract out to an efficient supplier achieving full economies of scale" (Mahoney, 1992:563). Such an argument has been put forward to explain why the auto industry has been increasing its use of outsourcing to spread the risk involved in development costs amongst themselves and their suppliers (Maher, 1997). Thus, auto manufacturers, rather than vertically integrating all their necessary supply services will enter into contractual agreements with suppliers. This alternative to vertical integration shares the financial risk of dedicating large sums of money to initiate manufacturing of new components as well as divesting parts supply to several possible sources. This is of particular importance in the auto industry as a work stoppage (strike) whether in house or, due to reliance on a single parts supplier, could shutdown manufacturing for all

automobiles. Thus, divestiture of parts supplies limits opportunism via a small numbers problem from outside the firm or opportunism from within the firm via an employee work stoppage.

## 5.10 Joint Venture

### 5.10.1 Defining a Joint Venture

In Section 5.8 joint ventures were defined as complex contracts in which parties to the venture have a claim to the residual of the investment. Complex contractual forms are necessary for pooling complementary assets owned by the separate firms and in most cases the parent firms combine part of their assets into a legally separate third-party entity and agree to share profits from the venture (Balakrishnan and Koza, 1993). Joint ventures are said to allow firms to share information, resources, markets, and risks to yield economies of scale (Gomes-Casseres, 1987).

Although joint ventures may be used for many purposes they are most common for investments characterized by risk and uncertainty. " [F]irms are most likely to concede some control if that will spread risk and expand expertise" (Anderson, 1990 : 20). In lieu of an outright acquisition, firms can form a joint venture for combining complementary assets.

The properties of an efficient joint venture are outlined by Balakrishnan and Koza (1993) as:

- A joint venture, unlike an acquisition, avoids a terminal sale and transfer of ownership rights and allows the partners to renegotiate the relationship at a relatively low cost. It can be structured as a mechanism that allows piecemeal transactions and renegotiations of compensation for individual contributions. The possibility of repeated contracting and termination of the relationship under a joint venture can induce information revelation and mitigate the adverse selection problem. There may be short-term gains from misrepresentations, but the threat of termination of the joint venture or its potential liquidation because of the resulting downstream inefficiencies, will offset these gains and reduce the incentives to misrepresent.

- Unlike a lease, the joint venture introduces, for each party, limited formal and informal property rights and obligations by the way of shared ownership. When the joint venture is formed as a partnership, the parties have a fiduciary responsibility to each other. In incorporated joint ventures the members of the governing board or the executive committee who are usually drawn from both the parent companies, collectively decide the policies of the joint venture. They may also have limited rights to formally or informally audit and verify the claims and actions of the firms by monitoring the use of the assets of their respective parent companies as well as those of the partner. These features of a joint venture, unavailable in a pure contract such as a leasing agreement, help to reduce the incentives for opportunistic behavior in the joint venture.

- The joint venture affords opportunities for learning and gathering new information about the value of the partner's assets. Some joint ventures explicitly stipulate a

dissolution date and many others end in purchase by one of the parents. In such cases, monitoring and auditing the partner's asset use facilitate the learning process and eventually, the pricing of those assets (Balakrishnan and Koza, 1993).

Thus, successful joint ventures entail a blending of individual talents from different firms to achieve a mutually desired and beneficial goal. Moss-Kanter (1994) outlines the properties necessary to form successful joint ventures:

- Individual Excellence: Both partners are strong and have something to contribute to the relationship.
- Importance: The partners have long-term goals that the relationship plays a key role [in the success of the joint venture].
- Interdependence: The partners have complementary assets and skills.
- Investment: They show tangible signs of long term commitment by devoting financial and other resources to the relationship.
- Information: Communication is reasonably open. Partners share information required making the relationship work.
- Integration: The partners develop linkages and shared ways of operating so they can work together smoothly.
- Institutionalization: The relationship is given formal status, with clear responsibilities and decision processes.
- Integrity: The partners behave toward each other in honorable ways that justify and enhance mutual trust.
- Relative size: The partners are of comparable size and are therefore able to sustain comparable losses if the joint venture fails.

Adapted from Lyles (1987) and Moss-Kanter (1994)

### 5.10.2 Costs Associated with Joint Ventures

The complexity of joint ventures imparts significant transaction costs on the members to coordinate the combining of assets. Joint ventures give to its participating agents a claim on the outputs of the operation that thusly reduces the incentive for opportunism. However, incentives for opportunism are not eliminated. Each joint venture party holds only a portion of the investment and can therefore only claim a portion of the benefits. Thus, either party may still find it advantageous to maximize its own gain at the expense of the venture.

Shared control, and the lack of a single interest dictating the gains and losses from the joint venture, can be the cause of costly disputes. Therefore, the benefits of joint ventures are sometimes offset by their costs (Hennart, 1991). In fact, a study by McKinsey and Coopers and Lybrand (1986) found that seventy percent of joint partnerships eventually broke up. This indicates that the transactions costs associated with joint ventures are significant, resulting in a high degree of instability that is a sign that the organizational form is prone to failure (Gomes-Casseres, 1987). The transaction cost efficiency of a joint venture hinges on the convergence (or divergence) of the goals of the parties to the agreement

### 5.10.3 Examples of Joint Ventures

Many governments legislate that for a foreign company to produce or even sell their products in that legislative jurisdiction, it must form a joint venture partnership with a domestic firm. As such, "fully half of new overseas investments may be on a

less-than-fully-owned basis" (Contractor, 1984:30). The rational is that such joint ventures offer domestic firms better access to technology and foreign management resources held by the foreign firm in question. Such forced joint ventures, however, may not reflect the true (most transaction cost efficient) governance structures of firms and, hence do not provide useful insights.

Joint ventures are contractual arrangements that provide a means to temporarily fit the different strengths of partners together so that value to both firms is achieved. Such advantages may be for purely legislative reasons, such as, allowing entry into a market behind a tariff wall. However, firms also form joint ventures to combine the resources and expertise needed for the development of new products, technologies or markets. Thus, if a firm chooses to enter into a new area of operations, perhaps vertically integrating up or down the production chain, then joint ventures are a means of accessing the expertise of an existing firm without actually purchasing the other firm. An example of this would be the 1984 *New United Motor Manufacturing* joint venture between General Motors (GM) and Toyota to produce subcompact cars (Wheelen and Hunger, 1990). At the time, GM had little expertise in the manufacture of smaller automobiles that were popular with consumers. Toyota was facing legislative barriers to entry to the US market. Therefore, a synergistic agreement between the two firms to produce sub-compact automobiles for the US market was possible since the agreement opened opportunities for both firms.

The formation of the close ties required by joint ventures can cause friction between the firms involved. For example, one partner in the venture may feel as though the other partner threatens control of their operations. Similarly, distribution of benefits

from the arrangement may have been determined ex-ante, but changing circumstances may have altered the relative values for the joint venture partners. For example, in the case of the agreement between GM and Toyota for the production of sub-compact automobiles, if legislation in the US were to change such that Toyota no longer faced legislated barriers to entry then the relationship with GM would no longer be of value to them. Hence, Toyota would likely wish to exit the joint venture since GM would be considered just another competitor for Toyota. In such a situation, Toyota would not want GM to have access to proprietary information specified in a joint venture relationship.

Although joint ventures may offer an alternative for businesses wishing to expand their operations into new areas, such agreements entail business complexities that are open to risk. Such problems represent the source of transaction costs:

> ... [C]apital infusions, transfer pricing, licensing fees, compensation levels, and management fees. Also, the complexity of roles each partner has with respect to the other can make economic decisions difficult... [As] the relationship is larger than one venture.
>
> (Moss-Kanter, 1994: 105)

At one point the agreement between Fisher Body and GM approached that of a joint venture. In the 1919 agreement GM acquired a 60% interest in Fisher via the purchase of 300,000 of Fisher's 500,000 shares of authorized common stock. Since both GM and the Fisher Brothers held a portion of Fisher Body, General Motors made an investment in Fisher Body for plant and equipment that was specific to GM. However,

despite owning the majority of the company the agreement entailed a voting trust[28] that ran until 1924. This gave the Fisher brothers (original owners of Fisher body) control of the company (Klein, 2000).

## 5.11 Contractual Forms

Given the number and complexity of contractual arrangements discussed in this chapter. A summary is provided in Table 5.1. The table uses the symbols ✓ and **X** to indicate whether the contract form is designed or is not designed to mitigate a given form of opportunism.

[28] A voting trust provides the trustee an irrevocable right to voting stock in a corporation for a designated period of time but does not give the trustee the right to sell the stock.

**Table 5.1 Summary of Governance Structures**

| | | Contracts | | | | | Joint Ventures | Vertical Integration |
|---|---|---|---|---|---|---|---|---|
| | | Market Price | Fixed Price | Cost Plus Profit | Indexed | Quality | | |
| Source of Opportunism | | | | | | | | |
| Uncertainty & Monitoring | Price | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Quantity | X | X | X | ✓ | ✓ | ✓ | ✓ |
| | Timing | X | X | X | ✓ | ✓ | ✓ | ✓ |
| Asset Specificity | Site | X | X | X | ✓ | ✓ | ✓ | ✓ |
| | Physical Asset | X | X | X | ✓ | ✓ | ✓ | ✓ |
| | Human Capital | X | X | X | X | X | ✓ | ✓ |
| | Dedicated | X | X | X | X | ✓ | ✓ | ✓ |
| Frequency of Transaction | | X | X | X | ✓ | X | ✓ | ✓ |
| Complexity of Exchange | | ✓ | ✓ | ✓ | X | ✓ | X | X |

✓ = market mechanism designed to handle this source of opportunism
X = market mechanism not designed to handle this form of opportunism

- Indexed contracts determine, ex-ante, that the burden of market uncertainty rests solely on one agent. It is unlikely that such a contract would be developed for an industry characterized by "transparent" neoclassical market prices. If this were the case then there would be no need for a contract, indexed or otherwise. Thus the industry in question would likely be typified by the ability for one contractual party to exact opportunism on the other. The source of such opportunism would likely be owing to site specificity. As such, concerns over price, quantity, timing and frequency would be written into the contract. It is worth noting that by writing a contract to cover opportunism due to quantity and timing may also cover frequency without is being explicitly stated.

- Quality contracts are primarily designed to ensure that the product promised is delivered, or purchased, at the quality agreed upon ex-ante. However, such contracts tangentially handle other forms of opportunism. Quality often entails that a product has a degree of perishability. Thus, to fulfil the ex-ante determined quality the product must be received and delivered at a specific time and schedule. Quality is also a function of quantity in that although the buyer may receive product of the ex-ante determined quality but if the quantity is less than was contracted it may not be profitable to process. Such a contractual situation would likely entail dedicated assets since there would not likely be alternative buyers or sellers that could be reasonably accessed. Thus, the nature of the contract would necessitate handling of site and dedicated asset specificity.

- Although vertical integration is not considered a contractual form it is representative of the opposite "end of the spectrum" with respect to spot market exchanges.

Vertical integration of business transaction internalizes what would otherwise be contractual relationships.

- Joint ventures, as were described in Section 5.10, are highly complex contracts to handle the sources of opportunism not covered by other contracts..
- Due to the complex nature of both joint ventures and vertical integration the complexity of exchange is a more prominent source of opportunism.

## 5.12 Conclusion

This chapter has reviewed the literature relevant to the hold-up problem. It should be clear that the existing literature focuses on the governance of individual transactions. This is consistent with the partial equilibrium approach of microeconomic theory.

The next chapter introduces the relationship between SaskPower, hog producers and biodigesters as a response to climate change issues. This relationship will entail governance structures involving dedicated assets, which are held by different agents in the above relationship. Chapter 6 will utilize the governance forms described in this chapter to examine incentives for opportunism in biodigester development.

# Chapter 6: Conceptual Framework

## 6.0 Introduction

This chapter focuses on developing a conceptual framework that models how the potential for opportunism, in different ownership structures, may affect the development of biodigesters in Saskatchewan. The chapter begins by listing the six ownership structures proposed to develop biodigesters in Saskatchewan. This is followed by a list of the five transactions used to compare incentives for opportunism in each of the organizational structures (Section 6.1). Section 6.2 lists the assumptions made for modeling the six organizational forms. Section 6.3 details why these six organizational forms were selected. Section 6.4 exemplifies, in tabular form, which transactions would be more prone to opportunism given each organizational form. Sections 6.5 to 6.10 illustrate each organization schematically, detail the governance structure, the risks of opportunism and then examine the possibility of opportunism for each transaction. Section 6.11 concludes this chapter and introduces Chapter Seven.

Throughout this chapter the abbreviation SPC is used interchangeably with SaskPower so as to keep section titles to a limit of one line. This makes the process of creating a table of contents much neater.

## 6.1 Organizations and Incentives for Opportunism

The six ownership strategies for biodigesters are:

1. SaskPower purchasing GHG credits from the Barn/biodigester as an outside party.
2. Hog barn operates the biodigester as a joint venture with SaskPower.
3. A third party manages the biodigester as a joint venture with SaskPower.
4. SaskPower vertically integrates both hog production and the biodigester.
5. SaskPower owns and operates the biodigester.
6. Hog barn and biodigester are operated as a joint venture for SaskPower and a hog barn management firm (HBF).

Within these organizational forms there are five transactions which have the potential to be open to opportunistic behavior by one or more participants in the following transaction(s).

GHG Offsets

NPK Concentrate

Energy

Hogs

Manure

Throughout this discussion it is important to remember that the literature reviewed in Chapter 5 examined cases involving only one transaction at a time. This research involves a departure from the single transaction model and, instead, uses TCE to search for an organization that best mitigates the threats of opportunism arising from multiple transactions occurring simultaneously. The following sections present the results of options available to SaskPower if it wishes to develop biodigesters in Saskatchewan.

## 6.2 Assumptions for the Organizational forms

There are a number of assumptions underlying the potential organizations.

1. SaskPower is interested in biodigesters for the purpose of earning GHG credits;
2. For GHG reductions, there is a "cap and trade system"[29] in place;
3. SaskPower wants to reduce its emissions by reducing demand on its existing coal fired generating capacity;
4. Demand for electricity is increasing in Saskatchewan. This is important since SaskPower will be seeking new means from which to source electricity. This will increase pressure for new technologies like biodigesters, to handle the increase in demand.
5. Stronger legislation regarding hog barn effluent management is likely in the future.
6. Electrical generating capacity from biodigesters is small relative to SaskPower's existing market. Thus, the primary market for biodigester electricity will be self-provision for the barn itself and supplying the electrical grid is a secondary consideration.
7. SaskPower will retain control over transmission and distribution facilities in the province for the foreseeable future.
8. There is a market for NPK concentrate from the biodigester.
9. There is sufficient interest and funding to realize biodigester type projects.
10. Biodigester technology is workable and financially viable in Saskatchewan.
11. Given IPCC or comparable standards for GHG emissions from hog manure in intensive hog operations, the capture and burning of methane from these operations is an accepted means of GHG reduction.
12. The biodigester is a stranded asset and cannot be moved.
13. Carbon credit exchange is fluid and the price of these credits reflects changes in supply and demand.
14. The NPK concentrate market is perfectly competitive and has no barriers to entry.
15. Manure has a financial value to farmers as fertilizer. This financial value can be thought of as opportunity cost for the manure that is being consumed by the biodigester.
16. The generating turbines are non-stranded assets and can be bought, sold or moved easily.

[29] A cap and trade system entails government imposing a maximum level of carbon emissions and allowing firms to trade excess carbon emission "credits" if they have excess.

## 6.3 Selection of an Organizational Form

Each organizational form presented in Section 6.0 presents its own strengths and weaknesses for reducing uncertainty owing to the prospect of opportunistic behavior. However, the selection of one organizational form based upon its ability to handle opportunism for one transaction may leave parties to the agreement open to opportunism from another transaction.

Although there are many potential organizational forms there are only six discussed in this thesis. Of the six, only one involves SaskPower not holding a financial stake in the biodigester (Organization # 1: SaskPower purchases credits from the barn / biodigester). This results from the assumptions that interest in digesters is motivated by SaskPower's desire for GHG offsets. Adoption of biodigesters by hog operations is very expensive and it is unlikely that individual hog barns would be willing to assume the risks associated with designing and installing biodigester systems.

A known value for GHG credits would perhaps be seen as an economic opportunity. However, no system is in place for the trading of such credits. Since climate change regulations are not likely to be enforced on hog barns, only businesses that release GHGs in their normal operations face a degree of uncertainty regarding future climate change legislation. Thus, it tends to be emitters of GHGs (like SaskPower) who are primarily interested in such research. As a result, it is unlikely that hog barns would be willing to invest the relatively large sums of money necessary to design and implement successful biodigester technology.

## 6.4 Possibility of Opportunism in the Six Organizational Forms

All six organizational forms hold possibilities for opportunistic behavior given the relevant transactions. Table 6.1 illustrates the possibility for opportunism by using an "X" for those transactions with a higher propensity for opportunism and using a "✓" for those with a lower propensity for opportunism. This table offers a simple presentation of the possibilities for opportunism given a specific transaction.

For example, organizational #1 is subject to opportunism for the transaction involving GHG offsets or the transaction involving energy. However, the organizational form holds little chance of opportunism in the areas of NPK concentrate, hogs and the flow of manure. This is explained in further detail in Section 6.6.

Similarly, organizational #4 presents little risk of opportunism in the transactions involving NPK concentrate and hogs. However, is open to opportunism in the transactions for GHG offsets energy and manure. This is explained in further detail in Section 6.9.

It would be misleading to suggest that all opportunism in all transactions hold the same potential to nullify the agreement between the economic agents. Rather, this table serves as an introduction to a more in depth analysis of the incidence and relative impact of opportunism given the transactions.

**Table 6-1 Table of Organizational Forms**

| | SaskPower as a Purchaser of Credits from the Barn/biodigester Organization#1 | Hog Barn Operates Biodigester as J.V. with SaskPower Organization#2 | Third Party Operates Biodigester as a J.V. With SaskPower Organization #3 | SaskPower Vertically Integrates Hog Production and Biodigester Organization#4 | SaskPower Owns and Operates Biodigester Organization#5 | Hog Barn and Biodigester as a J.V. for SaskPower Organization#6 |
|---|---|---|---|---|---|---|
| GHG Offsets | X | X | X | ✓ | X | X |
| NPK Concentrate | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Energy | X | X | X | ✓ | X | X |
| Hogs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Manure | ✓ | X | X | ✓ | X | X |

✓ = opportunism unlikely
X = possibility of opportunism

## 6.5 Detailed Analysis of Organizations # 1 through #6

The following sections present the relevant set of options faced by SaskPower if it wishes to develop biodigesters in Saskatchewan.

## 6.6 SPC Purchases GHG Credits from the Barn/Biodigester: Organization #1

Organization #1 involves SaskPower as an outside purchaser of GHG credits and energy from the barn/biodigester. Since SaskPower holds no equity in the barn/biodigester, the transactions for GHG credits and electricity would take place in the form of ex-ante contractual arrangements. The energy balance between SaskPower and the barn/biodigester is bi-directional with energy being sold in times of excess production from the barn/biodigester and drawn from the SaskPower grid in times of deficit. NPK concentrate would be sold to an outside party.

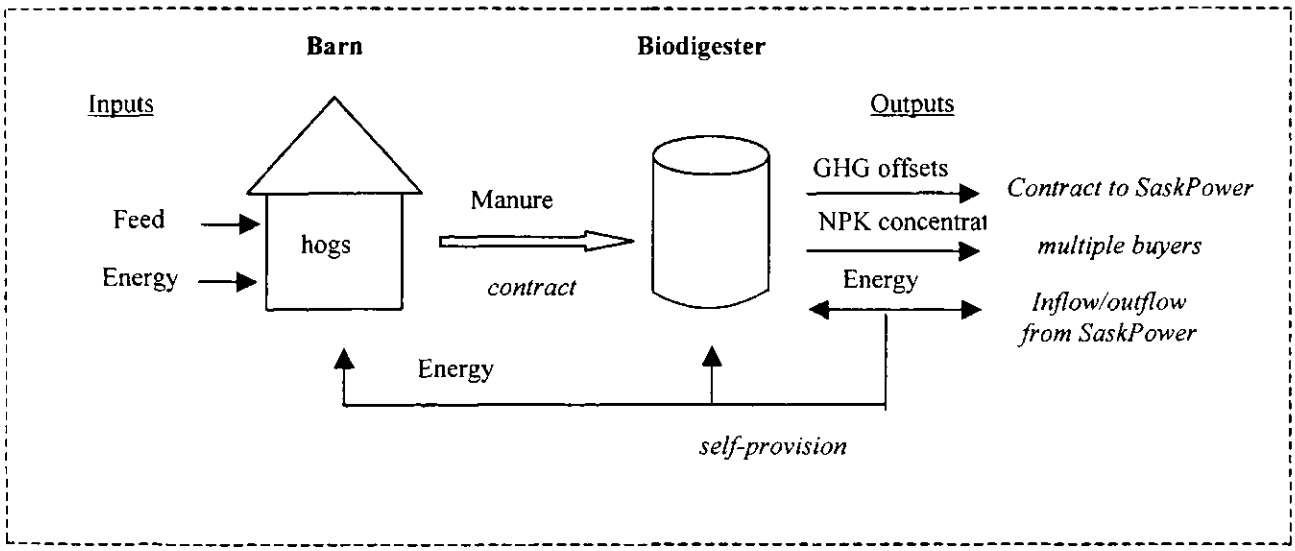



**Figure 6-1 Biodigester/Hog Barn Entity Sells Credits to SaskPower**

Given uncertainty over the barn / biodigester's ability to provide a consistent supply of energy, it is likely that SaskPower would purchase electricity under its Small

Producers Program[30] for $0.02 per kWh. The transaction of GHG credits contains several possibilities for incurring transaction costs and related opportunism. If the credits produced by the barn/biodigester were verifiable by an external regulating body then SaskPower would have no uncertainty requiring monitoring. However, if this were not the case, transaction costs would have to be incurred by SaskPower for monitoring the validity of the GHG credits[31].

The market for NPK concentrate would likely be part of the fertilizer market, whether that be agricultural or residential. Thus, it is unlikely there would be much room for opportunistic behavior between SaskPower and the barn/biodigester.

Regarding the flow of manure, opportunism would be unlikely since it would be a pure internal transfer between barn and biodigester and hold no incentive for opportunism.

The nature of transactions and opportunism will be covered in greater detail in Sections 6.6.1, 6.6.2 and 6.6.3.

[30] The Small Producers program is described in detail in Chapter 3. This program would leave the digester open to cancellation of the contract on short notice.
[31] Monitoring would entail determining that the Barn/digester are producing the quantity and quality of GHG credits stipulated by the contract.

### 6.6.1 Governance and Contractual Agreements for Organization #1

There are several forms of contractual agreements that could be applicable to this organizational form. These contracts are illustrated in Table 6.2 and are drawn from material detailed in Chapter 5.

**Table 6-2 Contractual Forms and Related Opportunism: Organization #1**

| Source of Opportunism | | Contracts | | | | |
|---|---|---|---|---|---|---|
| | | Market Price | Fixed Price | Cost Plus Profit | Indexed | Quality |
| Uncertainty & Monitoring | Price | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Quantity | X | X | X | ✓ | ✓ |
| | Timing | X | X | X | ✓ | ✓ |
| Asset Specificity | Site | X | X | X | ✓ | ✓ |
| | Physical Asset | X | X | X | ✓ | ✓ |
| | Human Capital | X | X | X | X | X |
| | Dedicated | X | X | X | X | ✓ |
| Frequency of Transaction | | X | X | X | X | X |
| Complexity of Exchange | | ✓ | ✓ | ✓ | X | ✓ |

✓ = market mechanism designed to handle this source of opportunism
X = market mechanism not designed to handle this form of opportunism

Whatever the contract between SaskPower and the barn/biodigester, for Organization #1, it would have characteristics similar to those mentioned in Table 6.2[32]. Different forms of contracts are designed to handle differing forms of opportunism. Choosing a contractual form to handle the sources of potential opportunism entails balancing the transaction costs of constructing the contract against the potential costs of opportunistic behavior.

For example, if SaskPower and the barn/biodigester chose a market price, fixed price or a cost plus profit contract, this would reduce uncertainty over price. Such simple contracts would not be open to opportunism due to complexity. However, they would do little to handle opportunism from other forms. As hog barns and biodigesters are characterized by specific assets and depend upon frequency of transaction, more complex contracts (indexed and quality contracts) are required to handle such opportunism.

Indexed and quality contracts help mitigate incentives for opportunism via dedicated assets and ensure a level of monitoring for quality of the inputs. However, such contracts entail a greater degree of complexity and the possibility of opportunism is by no means eliminated. Thus, although these contracts reduce uncertainty, opportunism may be merely diluted and not prevented. This could perhaps necessitate more costly monitoring to ensure that the details of the contract are not being used to leverage opportunism.

[32] The material in this table is described in further detail Chapter 5.

Whatever form of contractual arrangement is chosen, it will be subject to some form of opportunism.

### 6.6.2 Risks of Opportunism for Organization #1

In Organization #1, all transactions between the barn and the biodigester are internal; thus, incentives for opportunism between these parties are minimal. However, for SaskPower to attain GHG credits it must enter into a contractual agreement with the barn / biodigester. Such a contractual arrangement would be designed to minimize SaskPower's uncertainty over the future value of carbon emissions. Hence, SaskPower would be informally hedging against increases in the value of atmospheric carbon. Conversely, the barn/biodigester would be looking to the contract to minimize their exposure to the possibility of future low prices for carbon. The existence of a purely contractual arrangement between SaskPower and the barn / biodigester entity for the purchase of GHG credits does offer flexibility to both parties[33]. However, it does not necessarily provide the certainty that SaskPower is seeking for GHG credits.

Manifestations of opportunism would likely be in the form of ex-post renegotiations. Examples of such opportunism can be categorized as either inherent or circumstantial.

Inherent: In the event that GHG credits become significantly more valuable than the price contracted with SaskPower, then the hog barn could

[33] Whatever contract is written it must attempt to account for all possible contingencies. However, in attempting to cover all contingencies, the cost of the contract increases. This, in itself, is a transaction cost (complexity of agreement).

threaten to shut down its operations unless SaskPower is willing to pay a higher price for them (specific assets).

Circumstantial: If hog prices were to drop then the barn could say that it must receive more money to stay in business or else it will shut down the barn. This would effectively mean shutdown for the biodigester since the asset is immobile and the supply of manure would be cut off (specific assets).

### 6.6.3 Transactions and Opportunism: Organization #1

The following table (Table 6.3) illustrates sources of opportunism according to the previously mentioned transactions in Organization#1, SaskPower Contracts GHG Credits from Barn / Biodigester. Each transaction takes into account only the two agents and is not concerned with other agents along the supply chain.

**Table 6-3 Presence of Characteristics for Opportunism: Organization #1**

| | GHG Offsets | NPK Concentrate | Energy | Hogs | Manure |
|---|---|---|---|---|---|
| Specific Assets | potential for opportunistic behavior | little chance for opportunistic behavior | potential for opportunistic behavior | of low concern since only one producer and many buyers | internal transaction little risk of opportunism |
| Frequency | little chance for opportunistic behavior | little chance for opportunistic behavior. | little chance for opportunistic behavior | of low concern since only one producer and many buyers | internal transaction little risk of opportunism |
| Uncertainty and Monitoring | potential for opportunistic behavior | little chance for opportunistic behavior | potential for opportunistic behavior | of low concern since only one producer and many buyers | internal transaction little risk of opportunism |
| Complexity of Agreement | important and potentially a source of opportunism | little chance for opportunistic behavior | potential for opportunistic behavior | of low concern since only one producer and many buyers | internal transaction little risk of opportunism |

Following the format of Table 6.3 the possibility of opportunism is segregated according to transaction:

Manure: As the barn / biodigester is a single entity there is no incentive to behave opportunistically over the flow of manure. However, if the price for the raw manure were to increase sharply then the Hog Barn / biodigester as an entity may decide that it is more profitable to sell the raw manure than to use it to power the biodigester. This would mean that the GHG credit generation

capacity would cease and that energy would be demanded by the barn/biodigester from the SaskPower grid

GHG Offsets: The ownership of the GHG credits belong to the barn / biodigester operation and are contracted by SaskPower. If SaskPower is depending on this as a means of generating carbon credits, then they will lock in on a contract price for these credits agreed upon ex-ante. If the value of these credits increases then there is still the chance of the barn / biodigester acting opportunistically by trying to "renegotiate" the price for GHG credits. Alternatively, if the price of GHG credits is significantly lower than the contract price, then SaskPower may have an incentive to renegotiate the price for GHG credits with the barn / biodigester.

NPK Concentrate: The fact that the fertilizer market is characterized by a relatively large number of buyers and sellers may reduce the likelihood of opportunistic behavior. If a situation of low fertilizer prices developed, then the barn/biodigester may try to renegotiate its contract with SaskPower in an attempt to offset some of its losses from fertilizer production.

Energy: The primary use for energy from the biodigester is self-provision for the barn and biodigester. There is no room for opportunism in this exchange. As for residual energy that is destined for the grid, it is likely that SaskPower would purchase this under its existing

Small Producers Program in which they pay $0.02 per kWh and all set up costs for entering the grid are paid by the independent producer and not SaskPower. Where the potential for opportunism could arise is if the Hog Barn decides that it wishes to cease using a biodigester to self-produce its own electricity and it wants to purchase all of its electricity from the grid. This would be a significant departure from the original plans for the biodigesters. SaskPower may not want to provide electricity to the Hog Barn since it would increase demand on their existing generating capacity[34]. Recall that self provision should allow SaskPower to reduce its generating capacity.

Hogs: It is assumed that hogs are the main interest of the barn / biodigester. Due to the biodigester's dependence on the flow of manure from the barn, this means that whatever occurs in the hog operation will be of direct consequence to the biodigester. Thus, any change in feeding regime could have an effect on the output from the biodigester. A change in feeding regime to maximize profits for the Hog Barn could have direct consequence on the manure supply and could result in the maximization of gain from the Hog Barn at the expense of biodigester output. This is important in that actions taken to make hog production more profitable may be in conflict with fulfilling the contract

[34] If Hog Barns wish to draw electricity form the grid, it could cause problems for SaskPower given their legislative obligation to supply electricity to Saskatchewan.

obligations of the digester (i.e. maintaining GHG credit production). This would encourage the barn/digester to renege on its contractual obligations.

No matter what contract is written it could be subject to opportunism from ex-post renegotiations. For example, the barn / biodigester may claim that since hog prices have fallen the contract price of GHG credits must be increased or the alternative will be bankruptcy. Similarly, SaskPower may wish to terminate the contract early if GHG credits turn out to be worth significantly less than the price in the original contract. The incentive for ex-post opportunism is dependent upon comparing the transaction costs vs. the benefits of breaking the contract. Perhaps circumstances could change so much that either one of the agents could decide that it would be better to renege on the contract and risk the chance of losing a legal challenge for breaking the contract.

## 6.7 Hog Barn Operates Biodigester as a J.V. with SaskPower: Organization #2

In organization#2 the Hog Barn operates the biodigester as a separate joint venture entity with SaskPower. As an investor in this entity, SaskPower receives a return to its investment in the form of an ex-ante determined amount of GHG credits and a proportion of revenues (from the other outputs of the biodigester) based upon their level of investment. The flow of energy for the biodigester is bi-directional. Any excess capacity could be sold into the electrical grid at a price established by SaskPower. At times when the biodigester runs at an energy deficit, energy is drawn from the SaskPower grid.

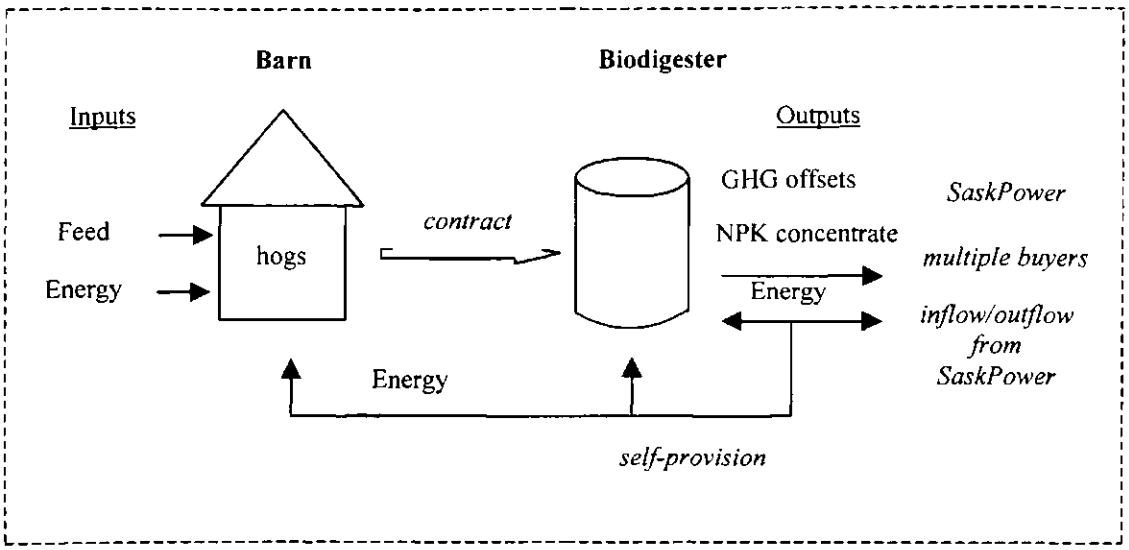



**Figure 6-2 Biodigester is operated by the Hog barn as a J.V. with SaskPower**

Relative to other organizational forms, SaskPower as a joint venture partner, would have greater access to knowledge of the actual financial situation for operation of the biodigester and would be better equipped to counter arguments of necessary infusions of funds to keep the entire enterprise from bankruptcy.

For the GHG credits, the market will depend on the nature of investment in the biodigester operation. SaskPower, by choosing to invest in such operations, would be attempting to offset the GHG impact from their electrical generation. Therefore, they would be expecting to receive GHG credits from the biodigester that would be valued at an ex-ante price. If the barn / biodigester had carbon credits in excess of that contracted

by SaskPower then, the GHG credits could be sold in whatever market exists for GHG credit trading.

The flow of manure would not be a pure internal transfer from the barn to the biodigester. The biodigester, although under the administration of the barn, is a separate economic entity. As such, the barn may use it to leverage opportunistic rents from SaskPower by restricting the flow of manure. Similarly, if the barn is facing low hog prices they might try to exact funds from SaskPower via the biodigester.

The nature of transactions and opportunism will be covered in greater detail in Sections 6.7.1, 6.7.2 and 6.7.3.

### 6.7.1 Governance and Contractual Agreements for Organization #2

For transactions outside the boundaries of the joint venture there are several forms of contractual agreements that could be applicable. Since the same contractual possibilities were covered in Table 6.2, the subsequent table (Table 6.4) will focus on the characteristics of a joint venture.

**Table 6-4 Joint Venture Sources of Opportunism: Organization #2**

| Source of Opportunism | | Joint Ventures |
|---|---|---|
| Uncertainty & Monitoring | Price | ✓ |
| | Quantity | ✓ |
| | Timing | ✓ |
| | Frequency | ✓ |
| Asset Specificity | Site | ✓ |
| | Physical Asset | ✓ |
| | Human Capital | ✓ |
| | Dedicated | ✓ |
| Frequency of Transaction | | ✓ |
| Complexity of Exchange | | X |

✓ = market mechanism designed to handle this source of opportunism
X = market mechanism not designed to handle this form of opportunism

A joint venture is an ownership structure involving both agents. Ownership provides disincentives to both parties to act opportunistically. The rational is that behaving opportunistically would result in damage both to the non-opportunistic agent and the opportunistic agent. However, if the likelihood to profit from opportunistic behavior is greater than the potential for self-damage, then opportunism is likely to take place.

As can be seen in the Table 6.4, a joint venture contains mechanisms designed to deal with opportunism from monitoring, asset specificity and frequency of the

transaction. However, the complexity of the agreement is a source of opportunism in itself. The joint venture is designed to mitigate incentives for opportunism but does not eliminate all possibilities of opportunism in these transactions (see Table 6.4).

### 6.7.2 Risks of Opportunism for Organization #2

A joint venture grants its participating agents (SaskPower and the Hog Barn) a claim on the outputs of the operation and this reduces the incentive for opportunism. However, such incentives for opportunism are not eliminated. Each joint venture party has only a portion of the investment and can, therefore, only claim a portion of the benefits. Thus, either party may still find it advantageous to maximize its own gain at the expense of the venture.

Examples of inherent and circumstantial opportunism for Organization #2 are as follows.

| | |
|---|---|
| Inherent: | If the value for GHG credits is lower than that which was predicted by SaskPower, they may wish to pay a lower price for them. Although both parties have a vested interest in making the digester a success, SaskPower might find it more profitable to "renegotiate" the contract than to continue to pay a "high" price for GHG credits. |
| Circumstantial: | The Hog Barn could threaten that it is not profitable for them to remain in this sort of operation and must close down both the Hog Barn and no longer run the digester. Stranded assets would |

reinforce the threat. Thus, the Hog Barn can demand greater infusion of funds or renegotiate the contract.

### 6.7.3 Transactions and Opportunism: Organization #2

The following table (Table 6.5) illustrates sources of opportunism according to the transactions for Organization #2, Hog Barn Operates Biodigester as J.V. with SaskPower. Each transaction takes into account only the two agents and is not concerned with other agents along the supply chain.

**Table 6-5 Joint Venture Sources of Opportunism Given Different Outputs**

| | GHG Offsets | NPK Concentrate | Energy | Hogs | Manure |
|---|---|---|---|---|---|
| Specific Assets | potential for opportunistic behavior | potential for opportunistic behavior | potential for opportunistic behavior | of low concern since only one producer and many buyers | important and potentially a source of opportunism |
| Frequency | little chance for opportunistic behavior | little chance for opportunistic behavior | potential for opportunistic behavior | of low concern since only one producer and many buyers | important and potentially a source of opportunism |
| Uncertainty and Monitoring | potential for opportunistic behavior | little chance for opportunistic behavior | potential for opportunistic behavior | of low concern since only one producer and many buyers | important and potentially a source of opportunism |
| Complexity of Agreement | important and potentially a source of opportunism | little chance for opportunistic behavior | potential for opportunistic behavior | of low concern since only one producer and many buyers | important and potentially a source of opportunism |

As stated earlier, joint ventures may offer greater disincentives for opportunistic behavior relative to contracts but their increased complexity can outweigh these benefits, hence incentives for opportunism are not eliminated.

Manure: As a joint venture both the Hog Barn and SaskPower have incentives to make the biodigester work. Therefore, the hog-barn as an investor in the biodigester joint venture would have a monetary disincentive to engage in behavior that negatively affects the flow of manure to the biodigester. However, if the price for the raw manure were to increase sharply then the Hog Barn / biodigester as an entity may decide that it is more profitable to sell the raw manure than to use it to power the biodigester. This would mean that the ability to generate GHG credits would cease and that energy would be demanded from outside sources. This would frustrate SaskPower if there is an agreed upon contract for the purchase of GHG credits. Conversely, if SaskPower decides that GHG credits are not worth their investment in the joint venture, then they could limit the ongoing investment they choose to put into the agreement.

GHG Offsets: The ownership of the GHG credits belong to the barn / biodigester operation. If SaskPower is depending on this as a means of generating carbon credits then they will lock in a contract price for these credits which is agreed upon ex-ante. If the value of these credits increases, ex post, then there is still the chance of opportunistic behavior on the part of the rest of the barn / biodigester by reneging on the joint venture agreement unless a

greater portion of the rents from the GHG credits are allocated to them.

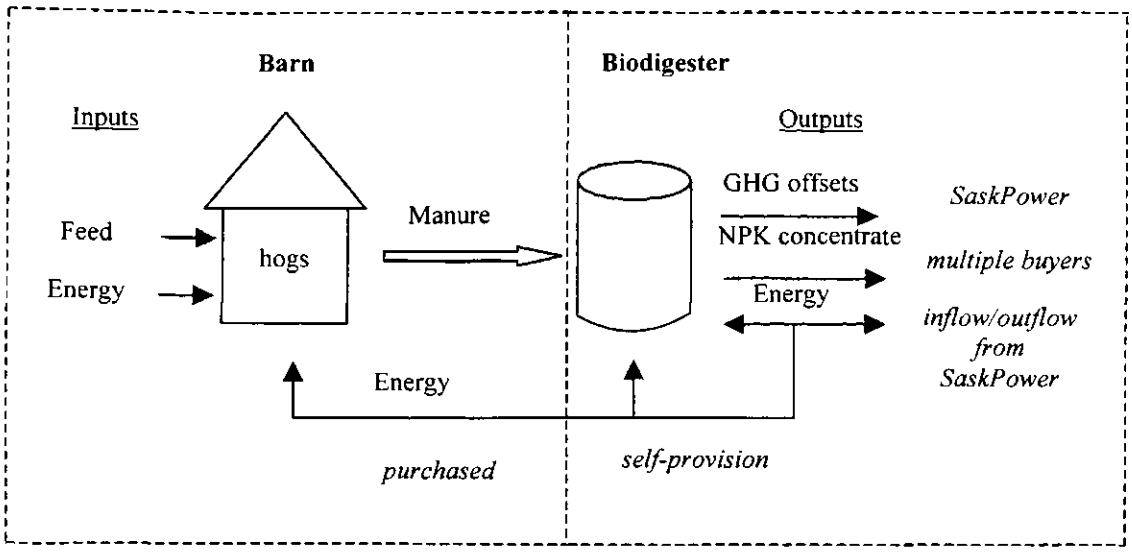
NPK Concentrate: Given that the fertilizer market is characterized by a large number of buyers and sellers, there is minimal likelihood of opportunistic behavior. There will be low monitoring costs regarding the price of manure (and NPK concentrate) since joint venture partners would be aware of the financial viability of the fertilizer operation.

Energy: The primary use for energy from the biodigester is self-provision for the barn and biodigester. There appears to be little room for opportunism in this exchange. However, the biodigester management may want to raise prices for the electricity produced from the biodigester to extract rents from the joint venture. As the barn holds a portion of the biodigester interest, this would seem unlikely. Where the potential for opportunism could arise is if the Hog Barn decides that it wishes to exit the joint venture and decides that it no longer wants to self-produce its own electricity, rather, it wants to purchase all of its electricity from the grid. This would be a significant departure from the original plans for the biodigesters. SaskPower would perhaps be reluctant to provide electricity to the Hog Barn because they have not planned to dedicate generation capacity to these barns.

Hogs: Hogs are assumed to be the main interest of the Hog Barn. Due to the biodigester's dependence on the flow of manure from the Hog Barn, this means that whatever occurs in the hog operation will be of direct consequence to the biodigester. Therefore, any change in feeding regime could have an effect on the output from the biodigester. Thus, a change in feeding regime to maximize profits for the Hog Barn could have direct consequence on the manure supply and could result in the maximization of gain from the Hog Barn at the expense of the venture.

## 6.8 Third Party Manages the Biodigester as a J.V. with SPC: Organization #3

In this form of market organization, the Hog Barn and the biodigester are operated as distinct economic entities. A third party, in a joint venture with SaskPower, owns and operates the biodigester.




Dashed line represents separation of barn and biodigester as distinct entities.

**Figure 6-3 A Third Party Manages the Biodigester as a J.V. with SaskPower**

This organization would require contractual agreements for the supply of manure from the Hog Barn and contracts for the sale of its outputs. Some of the energy would be used to supply the biodigester and any residual energy would be incorporated into the SaskPower grid at whatever price SaskPower dictates. Output of NPK concentrate from the biodigester would be sold in the market for the prevailing market price.

Although the fertilizer market may be characterized by a large number of buyers and sellers, there is the possibility of opportunistic behavior. Again, SaskPower could claim to the Hog Barn that low prices for fertilizer necessitate renegotiations of manure prices to remain viable.

The nature of transactions and opportunism will be covered in greater detail in sections 6.8.1, 6.8.2 and 6.8.3.

### 6.8.1 Governance and Contractual Agreements for Organization #3

Joint venture is the governance structure used in this organization, however, other contractual forms are necessary to manage transactions like the flow of manure and the generation of GHG credits. Table 6.6 includes the contractual forms cited in earlier tables to emphasize the importance of contracts regulating the relationship between the biodigester and the Hog Barn.

**Table 6-6 Applicable Sources of Opportunism for Organization #3**

| Source of Opportunism | | Contracts | | | | | Joint Ventures |
|---|---|---|---|---|---|---|---|
| | | Market Price | Fixed Price | Cost Plus Profit | Indexed | Quality | |
| Uncertainty & Monitoring | Price | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Quantity | X | X | X | ✓ | ✓ | ✓ |
| | Timing | X | X | X | ✓ | ✓ | ✓ |
| Asset Specificity | Site | X | X | X | ✓ | ✓ | ✓ |
| | Physical Asset | X | X | X | ✓ | ✓ | ✓ |
| | Human Capital | X | X | X | X | X | ✓ |
| | Dedicated | X | X | X | X | ✓ | ✓ |
| Frequency of Transaction | | X | X | X | X | X | ✓ |
| Complexity of Exchange | | ✓ | ✓ | ✓ | X | ✓ | X |

✓ = opportunism unlikely
X = possibility of opportunism

Contracts to ensure the flow of manure between the barn and biodigester would be in the form of those in Table 6.6. Again, the issue of trading transaction costs for minimizing incentives for opportunism plays an important role. Simple price contracts are inexpensive to negotiate; however, to deal with opportunism, arising from specific assets entails more expensive indexed or quality contracts. Although the latter mentioned contracts may provide better legal recourse if opportunistic behavior is suspected, incentives for opportunism still exist. This can be presumed since there are higher negotiation costs in setting up these contracts.

### 6.8.2 Risks of Opportunism for Organization #3

Although there is a joint venture agreement in place the barn and biodigester are under different management and there are several possibilities for opportunism.

Examples of inherent and circumstantial opportunism:

Inherent: The Third Party requires a contractual agreement for the flow of manure from the barn. Once the Third Party has a digester in place it is a stranded asset. If the Barn perceives a gain from breaking the contract would be greater than fulfilling the contract, there is an incentive for opportunism.

Circumstantial: If the Barn is dependent on the flow of energy for the digester. then the Third Party could threaten shutdown of their business claiming it is unprofitable. If the Barn does not have "normal" links into the gas and electricity grids, they would have to incur the expense of linking into these grids. If the price of linking to the grids is prohibitive, then the Barn may have to offer to renegotiate the price of manure as an incentive to keep the digester running.

### 6.8.3 Transactions and Opportunism: Organization #3

The following table (Table 6.7) illustrates sources of opportunism according to the transactions for Organization #3, Third Party Manages the Biodigester as a joint venture with SaskPower. Each transaction takes into account only the two agents and is not concerned with other agents on the supply chain.

**Table 6-7 Opportunism for Organization #3**

| | GHG Offsets | NPK Concentrate | Energy | Hogs | Manure |
|---|---|---|---|---|---|
| Specific Assets | potential for opportunistic behavior | many potential buyers thus opportunism unlikely | potential for opportunistic behavior | of low concern since only one producer and many buyers | important and potentially a source of opportunism |
| Frequency | potential for opportunistic behavior | many potential buyers thus opportunism unlikely | potential for opportunistic behavior | of low concern since only one producer and many buyers | important and potentially a source of opportunism |
| Uncertainty and Monitoring | potential for opportunistic behavior | many potential buyers thus opportunism unlikely | potential for opportunistic behavior | of low concern since only one producer and many buyers | important and potentially a source of opportunism |
| Complexity of Agreement | potential for opportunistic behavior | many potential buyers thus opportunism unlikely | potential for opportunistic behavior | of low concern since only one producer and many buyers | important and potentially a source of opportunism |

Manure: The flow of manure from the barn to the biodigester is a candidate for opportunism. An example of inherent opportunism on the part of the barn would be if the barn perceives the biodigester is very profitable and threatens to shut down manure supply to renegotiate the price being paid for manure. Similarly, if the price for the raw manure were to increase sharply, then the Hog Barn as an entity may decide that it is more profitable to sell the raw manure than to use it to power the biodigester. In either case, as inherent threats there could be legal action if the biodigester believes it would be more profitable than maintaining the contractual agreement.

Other forms of opportunism due to a drop in hog prices or changes in manure quality would be similar to those discussed for the previous organizational form. Again, the biodigester is then effectively held hostage to the profitability of the hog market. Since, the biodigester is an expensive asset that is immovable and has no salvage value, the biodigester is effectively tied.

Another area of potential disagreement between the barn and the biodigester would be regarding the quality of the manure. Any contract for the flow of manure would likely stipulate the quality and quantity of manure that the barn is to supply the biodigester. However, accurate monitoring of the actions within the barn would likely prove difficult. Hence, to maximize the profitability of the Hog Barn, its management may choose to change the feed rations they are giving their animals. This could affect the biodigester's operations given the methanogenic bacteria being used are specific to a consistent and predictable type of manure. Thus, changes in feed mix would necessitate changes in the type of bacteria being used to maximize biodigester operations. This would entail mechanisms for information exchange between the barn and the biodigester.

The possibility of manure contamination also represents a monitoring problem. If, for example, manure in the Hog Barn was contaminated with antibiotics or other agents that are

potentially toxic for the bacteria in the biodigester, this could result in biodigester shut down. Although the contract may specify repercussions for such events, the impact on biodigester operations would be expensive and difficult to compensate.

GHG Offsets: The ownership of the GHG credits belongs to the third party biodigester operation. If, however, events transpire that throw the supply of manure into question then GHG credit generation capacity would cease. This would frustrate the third parties efforts to meet their GHG credit contractual commitments.

NPK Concentrate: Although the fertilizer market is characterized by a large number of buyers and sellers there is the possibility of opportunistic behavior. The third party could claim to the Hog Barn that low prices for fertilizer necessitate renegotiations of manure prices to remain viable.

Energy: If the primary use for energy from the biodigester is self provision, there is no room for opportunism. However, if the Barn is depending on residual energy generated by the biodigester, then opportunism may arise from either the biodigester trying to renegotiate energy prices (via threatening shut down) or from the Barn threatening to end its purchase agreement with the biodigester.

Where the potential for contractual discord could arise is if the biodigester decides that it wants to shutdown and the hog-barn is

dependent upon it for energy. This would be a significant departure from the original plans for the biodigesters. However, the third party may have determined that biodigesters are unprofitable and not effective as a means to earn GHG credits. This would leave the Hog Barn in an awkward position of having to source its energy needs from natural gas and/or the normal electricity grid. This could represent a problem if the barn has not linked to these grids or if they have developed the barn based upon a lower price for energy being offered by the biodigester.

The recourse for the barn would be to seek legal action. However, this would be expensive and the potential benefits may not exceed the costs of losing the court case.

Hogs: Hogs are assumed to be the main product of the barn. Due to the biodigester's dependence on the flow of manure from the barn, this means that whatever occurs in the hog operation will be of direct consequence to the biodigester. Thus, any change in feeding regime could have an effect on the output from the biodigester. Low hog prices could also have serious consequences on the flow of manure (shut down of the hog operation).

## 6.9 SPC Vertically Integrates Hog Production and Biodigester: Organization #4

In this form of market organization the Hog Barn and the biodigester are operated as one economic entity within SaskPower. As owners, SaskPower incurs all expenses of management and receives all returns to its investment in the form of hogs, GHG credits NPK concentrate and energy.

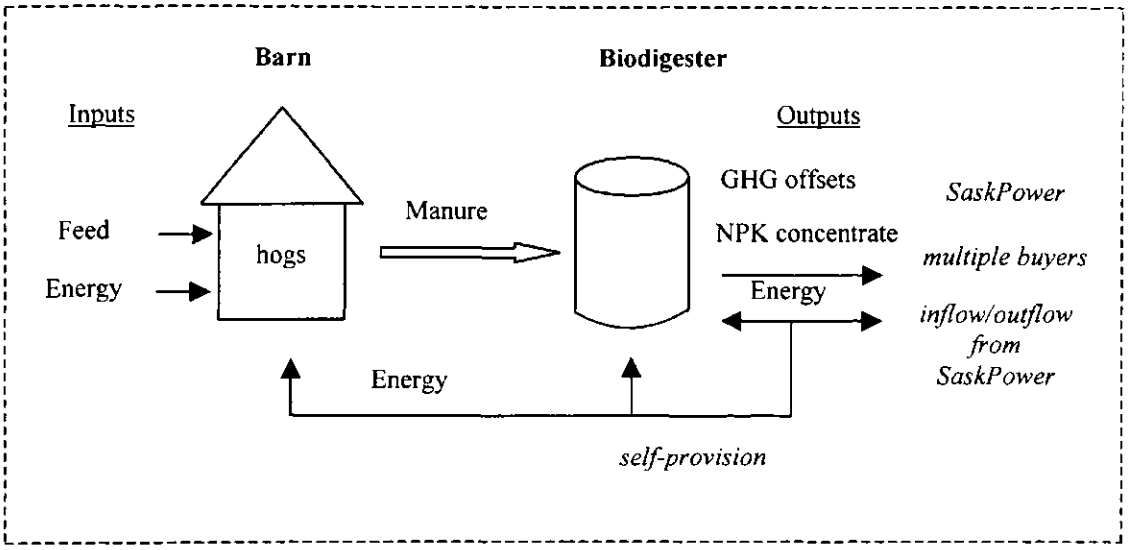



**Figure 6-4 SaskPower Operates Hog Barn and Biodigester**

The flow of energy for the biodigester is bi-directional. In times of excess, energy from the biodigester is used to offset energy demanded from outside sources to power the barn and the biodigester. Any excess capacity could be sold into the electrical grid. At times when the biodigester runs at an energy deficit, energy would be purchased from SaskPower's existing grid.

NPK concentrate output from the biodigester would be sold in the market for whatever the prevailing market would dictate. Since the fertilizer market is one of many

buyers and sellers it is unlikely that there would be undue incentives to extract opportunistic rents.

For the GHG credits SaskPower would receive any or all credits generated. SaskPower choosing to invest in such operations would be to offset the GHG impact from their electrical generation. Therefore, they would be expecting to receive GHG credits from the biodigester. If the barn / biodigester has carbon credits in excess of what SaskPower requires, then the GHG credits would be sold in what ever market exists for GHG credit trading.

The flow of manure would be an internal transfer from the barn to the biodigester such that there would be no external market.

### 6.9.1 Governance and Contractual Agreements for Organization #4

The vertical integration of the barn and biodigester by SaskPower internalizes transactions like the flow of manure, GHG credits, electricity and limits the transactions for hogs and NPK concentrate to outside buyers. However, where opportunism may arise is within the firm (organization) itself. This is illustrated in Table 6.8.

**Table 6-8 Sources of Opportunism Relevant to SPC's Vertical Integration**

| Source of Opportunism | | Vertical Integration |
|---|---|---|
| Uncertainty & Monitoring | Price | ✓ |
| | Quantity | ✓ |
| | Timing | ✓ |
| Asset Specificity | Site | ✓ |
| | Physical Asset | ✓ |
| | Human Capital | ✓ |
| | Dedicated | ✓ |
| Frequency of Transaction | | ✓ |
| Complexity of Exchange | | X |

Vertical integration of SaskPower into both biodigesters and hog operations would eliminate all of the incentives for opportunism from external agents. However, vertical integration is a form of governance and would require SaskPower to add an additional layer of managerial and technical expertise to enter into both the hog and biodigester markets. Incorporation of such new expertise into SaskPower is complex and would incur high transaction costs.

### 6.9.2 Risks of Opportunism for Organization #4

The argument in favor of SaskPower vertically integrating into hog production is to eliminate the inter-firm transaction costs and opportunism. Transactions, whether they be inter or intra-firm, hold incentives for opportunism. Each output from the barn /

biodigester entity each has differing levels of opportunism. Although actual incentives for opportunism can not be quantified once they are identified, it is possible to weigh them against other options.

SaskPower would have to incur large managerial costs to vertically integrate into hog / biodigester operations. Currently SaskPower is in the business of generating and distributing electricity. They have no managerial skills for the production of hogs and the management of hog operations. SaskPower would have to hire large numbers of staff who hold expertise in the raising of hogs. This would entail large search costs as well as the need to create an additional layer of management specifically for hog operations.

| | |
|---|---|
| Inherent: | Given the greater number of staff required to engage in Hog Barn / biodigester operations there is the increased possibility of labor unrest in the form of strikes to exact quasi rents from SaskPower (Ex-Post Renegotiations). |
| Circumstantial: | Given the complexity of such operations, employees could act more circumstantially than to actually go on strike by simply being non-cooperative and this not maximizing the generation of benefits from barn / biodigester. This may again require yet more staff to monitor subordinate staff to ensure they are not being non-cooperative. |

### 6.9.3 Transactions and Opportunism: Organization #4

The following table (Table 6.9) illustrates sources of opportunism according to the transactions for Organization #4, SaskPower Vertically Integrates Hog Production and Biodigester. Each transaction takes into account only the two agents and is not concerned with other agents on the supply chain.

**Table 6-9 Opportunism and SaskPower's Vertical Integration into Hogs**

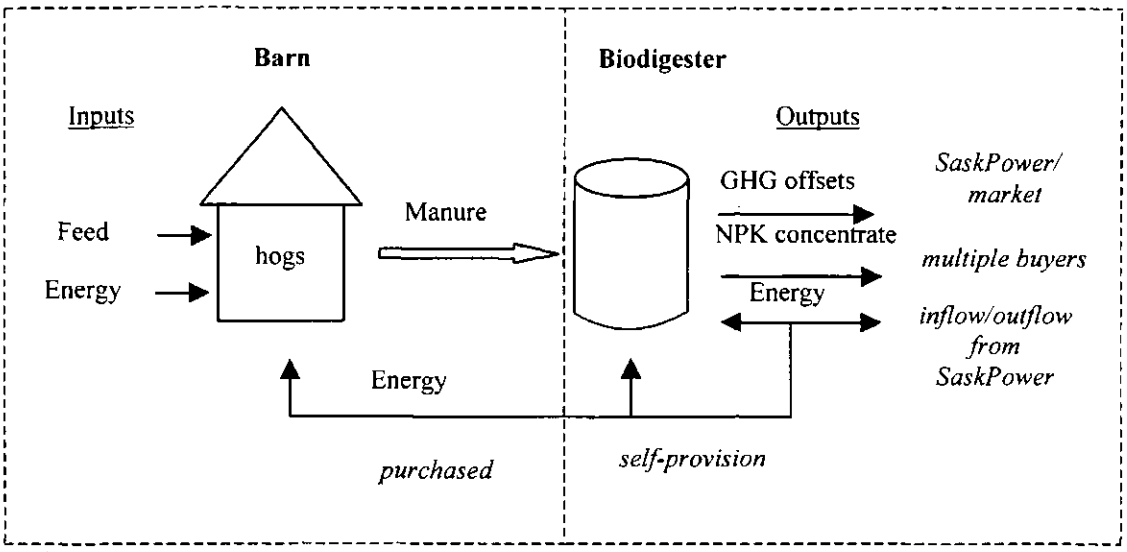
| | GHG Offsets | NPK Concentrate | Energy | Hogs | Manure |
|---|---|---|---|---|---|
| Specific Assets | no chance for opportunism | no chance for opportunism | no chance for opportunism | of low concern since only one producer and many buyers | no chance for opportunism |
| Frequency | transactions internalized thus, no opportunism | of low concern since subject to open market | transactions internalized thus, no opportunism | of low concern since only one producer and many buyers | transaction internalized thus, no opportunism |
| Uncertainty and Monitoring | transactions internalized thus, no opportunism | transactions internalized thus, no opportunism | transactions internalized thus, no opportunism | of low concern since only one producer and many buyers | transactions internalized thus, no opportunism |
| Complexity of Agreement | important and potentially a source of internal opportunism | transactions internalized thus, no opportunism | important and potentially a source of internal opportunism | important and potentially a source of internal opportunism | important and potentially a source of internal opportunism |

Manure: Since the flow of manure is under one managerial scheme there is little chance of exacting opportunistic rents. The only possible exception would be incompetence of Hog Barn employees (given labor unrest or incompetence) that would compromise the quality of manure. As such this might require considerable monitoring costs to ensure that the manure and the barn employees do not contaminate it.

| | |
|---|---|
| GHG Offsets: | The GHG credits belong to the barn / biodigester operation. Opportunism could be exacted within the firm given a scenario of labour unrest. Although it would complicate SaskPower's GHG credit plans, it could be dealt with within SaskPower's managerial structure. |
| NPK Concentrate: | Given that the fertilizer market is characterized by a large number of buyers and sellers, there is minimal likelihood of opportunistic behavior. |
| Energy: | The primary use for energy from the biodigester is self-provision for the barn and biodigester. There is no room for opportunism for this exchange. Any residual energy would be destined for SaskPower's grid. |
| Hogs: | The main goal of SaskPower, assumed within this thesis, is to gain GHG credits. Nevertheless, hogs would be an important output from this vertically integrated operation. Sources of opportunism would be similar to those described for other outputs, in that, they would be manifestations of intra firm opportunism or, a divergence of managerial goals between the Hog Barn's management and that of the parent company (SaskPower). |

## 6.10 SaskPower Owns the Biodigester: Organization #5

In Organization #5 the Hog Barn and the biodigester are operated as distinct economic entities. SaskPower owns and operates the biodigester and the hog-barn is operated by its own internal management. This means that SaskPower must add an additional layer to its management hierarchy for the operation of biodigesters. This would be expensive in terms of requiring additional staff and training as well as the ongoing expense of wages.




Dashed line represents separation of barn and biodigester as distinct entities.

**Figure 6-5 SaskPower Owns Biodigester**

As the sole owner of the biodigester, SaskPower would be the sole benefactor from whatever GHG credits are generated. Some of the energy could be used to supply the biodigester and any residual energy would be incorporated into the SaskPower grid. NPK concentrate output from the biodigester would be sold in the market for whatever the prevailing market would dictate. Since the fertilizer market is one of many buyers and sellers, it is unlikely that there would be undue incentives to exact opportunistic

rents. However, since there is a transaction for the flow of manure between the barn and the SaskPower biodigester, there are incentives to act opportunistically. For example, if hog prices are low the barn may try to renegotiate the ex-ante price for manure arguing that unless they are paid more they will go broke. SaskPower may be suspicious of this claim, but if they seek legal action it could simply ensure the barn fails. Such an information asymmetry is a typical condition for opportunism.

### 6.10.1 Governance and Contractual Agreements: Organization #5

Vertical integration makes the biodigester part of the SaskPower firm and can be described as a governance structure. As such, vertical integration of the biodigester controls opportunism via monitoring, specific assets and frequency of transaction for outputs of the biodigester (see Table 6.10). However, the flow of manure from barn to biodigester requires contractual agreements similar to those mentioned for Organization #1 and is, thus, prone to opportunism.

**Table 6-10 Sources of Opportunism for Organization #5**

| Source of Opportunism | | Vertical Integration |
|---|---|---|
| Uncertainty & Monitoring | Price | ✓ |
| | Quantity | ✓ |
| | Timing | ✓ |
| Asset Specificity | Site | ✓ |
| | Physical Asset | ✓ |
| | Human Capital | ✓ |
| | Dedicated | ✓ |
| Frequency of Transaction | | ✓ |
| Complexity of Exchange | | X |

Vertical integration of SaskPower into biodigesters would manage opportunism for stranded assets for the biodigester and their related transactions of GHG credit, NPK concentrate and electricity. The flow of manure into the biodigester would still require a contractual agreement similar to those mentioned for the previous organizational forms. Such contracts may mitigate some of the incentives for opportunism but they by no means eliminate them. Therefore, either party cold be held "for ransom" over the flow of manure between barn and biodigester.

### 6.10.2 Risks of Opportunism for Organization #5

SaskPower owning the biodigester would internalize many transactions. However, the flow of manure from the Barn would necessitate contracts.

Inherent: An example of inherent opportunism on the part of the barn would be if the barn perceives the biodigester as very valuable to SaskPower and threatens to shut down manure supply to renegotiate the price being paid for manure. Similarly, if the price for the raw manure were to increase sharply, then the Hog Barn as an entity may decide that it is more profitable to sell the raw manure than to use it to power the biodigester.

Circumstantial: The flow of manure could be terminated or the quality could be thrown into question given profit maximizing behavior on the part of the digester. Such actions would be difficult for SaskPower to handle without perusing legal action. The later is a lengthy and expensive process.

### 6.10.3 Transactions and Opportunism: Organization #5

The following table (Table 6.11) illustrates sources of opportunism for Organization #5, SaskPower Owns the Biodigester. Each transaction takes into account only the two agents and is not concerned with other agents along the supply chain.

**Table 6-11 Opportunism and SaskPower's Ownership of Biodigester**

| | GHG Offsets | NPK Concentrate | Energy | Hogs | Manure |
|---|---|---|---|---|---|
| Specific Assets | not open to opportunistic behavior | of low concern since subject to open market | potential for opportunistic behavior | of low concern since only one producer and many buyers | potential for opportunistic behavior |
| Frequency | not open to opportunistic behavior | of low concern since subject to open market | potential for opportunistic behavior | of low concern since only one producer and many buyers | potential for opportunistic behavior |
| Uncertainty and Monitoring | not open to opportunistic behavior | of low concern since subject to open market | potential for opportunistic behavior | of low concern since only one producer and many buyers | potential for opportunistic behavior |
| Complexity of Agreement | little chance for opportunism | of low concern since subject to open market | potential for opportunistic behavior | of low concern since only one producer and many buyers | potential for opportunistic behavior |

Manure: The flow of manure from the barn to the biodigester is a candidate for opportunism. Opportunism on the part of the barn would be possible if the market for hogs is in a prolonged downward cycle, then the Hog Barn could threaten to shut down operations unless SaskPower is willing to pay to keep the barn open. SaskPower is then effectively held hostage to the profitability of the hog market. The biodigester is an expensive asset, which is immovable and has no salvage value. Thus, due to information asymmetry regarding the financial situation of the barn, SaskPower must decide whether to take legal action which might ensure the demise of the barn or to give the barn what they want.

Another area of potential disagreement between the barn and the SaskPower biodigester is the quality of the manure. Whatever the contract for the flow of manure it would likely stipulate the quality and quantity of manure that the barn is to supply the biodigester. However, if the Hog Barn wishes to change its feed rations, to maximize profitability of their operation, this could affect the nature of the manure flowing to the biodigester. This in turn, could affect the performance of the biodigester and lead to conflict and costly measures to rectify.

The possibility of manure contamination also represents a monitoring problem. If, for example, manure in the Hog Barn was contaminated with antibiotics or other agents that are potentially toxic for the bacteria in the biodigester, this could result in biodigester shut down. Although the contract may specify repercussions for such events, the result for biodigester operations would be expensive and difficult to compensate.

The biodigester could also engage in activities that interfere with the profitability of the Hog Barn. For example, SaskPower may determine that a biodigester it simply unprofitable and shuts it down. If the Hog Barn is depending on the biodigester as a means of manure disposal or as a source of energy, then the barn must find alternatives for manure removal and energy. For energy supply, this should not likely be too difficult since the Hog Barn would have gas lines and electrical wires to supply their barn. However, manure disposal requires specific assets in the form of lagoons and equipment for transporting and spreading manure on fields.

GHG Offsets: The ownership of the GHG credits belongs to the SaskPower biodigester operation. There is no incentive for opportunism given the interests is restricted to those of the profit function. If, however, events transpire that throw the supply of manure into question then GHG credit generation capacity would cease. This

would frustrate SaskPower's efforts to meet their climate change commitments.

NPK Concentrate: Although the fertilizer market is characterized by a large number of buyers and sellers there is the possibility of opportunistic behavior. Again, SaskPower could claim to the Hog Barn that low prices for fertilizer necessitate renegotiations of manure prices to remain viable.

Energy: Where the potential for contractual discord could arise is if the biodigester decides that it wants to shutdown and the hog-barn is dependent upon it for energy. This would be a significant departure from the original plans for the biodigesters. However, SaskPower may have determined that biodigesters are unprofitable and not effective as a means to earn GHG credits and decide to either shut down or increase the price of electricity for the Hog Barn. This would leave the Hog Barn in an awkward position of having to source its energy needs from natural gas and / or from the normal electricity grid. This could represent a problem if the barn has not linked to these grids or if they have developed the barn based upon a lower price for energy being offered by the biodigester. The recourse for the barn would be to seek legal action. However, this would be expensive and the potential benefits may not exceed the costs. Further, there is the risk of losing the court case.

Hogs: Hogs are assumed to be the main product of the barn. Due to the biodigester's dependence on the flow of manure from the barn, this means that whatever occurs in the hog operation will be of direct consequence to the biodigester. Thus, any change in feeding regime could have an effect on the output from the biodigester. Opportunism could be inherently or circumstantially exacted.

### 6.11 Hog barn and Biodigester as a J.V. for SPC and an HBF: Organization #6

In this form of market organization SaskPower and a Hog Barn management firm (HBF) operate the Hog Barn and the biodigester as one economic joint venture entity. SaskPower is an investor in this entity and receives a return to its investment as an ex-ante determined proportion of GHG credits as well as revenues from the other outputs of the operation.

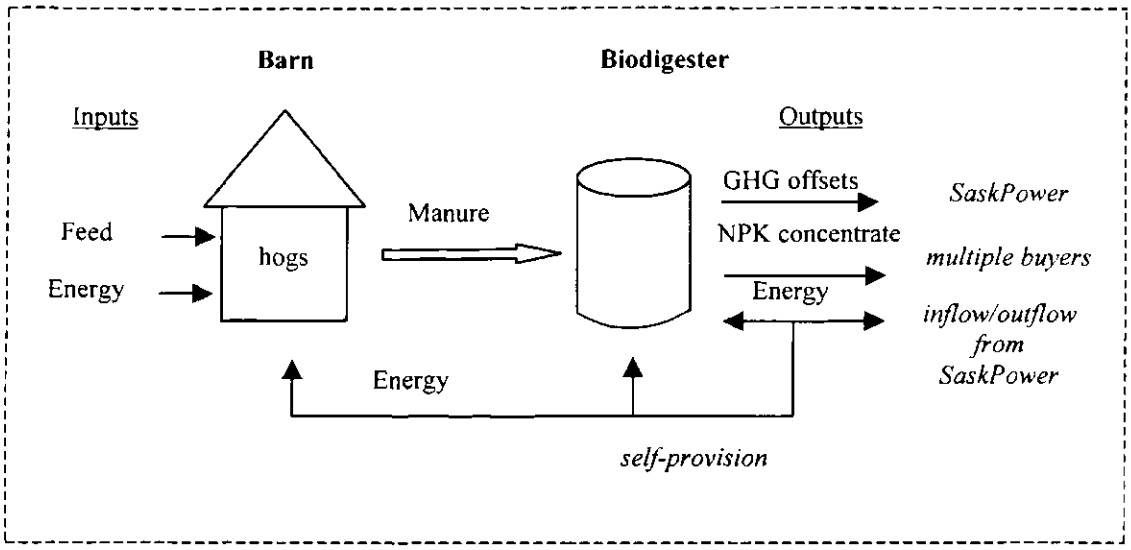



**Figure 6.6 Hog barn and Biodigester as a Joint Venture for SaskPower**

The flow of energy for the biodigester is bi-directional. In times of excess, energy from the biodigester is used to offset energy demanded from outside sources to power the barn and the biodigester. Any excess capacity could be fed into the electrical grid for an internal transfer price that SaskPower dictates. Conversely, at times when the biodigester runs at an energy deficit, energy is drawn from the SaskPower grid.

NPK concentrate output from the biodigester would be sold in the market for whatever the prevailing market would dictate. Since the flow of manure is internal, there would be undue incentives to exact opportunistic rents.

For the GHG credits, the market will depend on the nature of investment in the biodigester operation. SaskPower choosing to invest in such operations would be to offset the GHG impact from their electrical generation. Therefore, they would be expecting to receive GHG credits from the biodigester which would be valued at an ex-ante price. If the barn / biodigester had carbon credits in excess of what SaskPower

contracted then, the GHG credits would be sold in what ever market exists for GHG credit trading.

The flow of manure would be an internal transfer within the joint venture and there would be no external market.

### 6.11.1 Governance and Contractual Agreements: Organization #6

This joint venture involves both agents owning an ex-ante agreed upon portion of the barn and biodigester. Such ownership provides disincentives for opportunistic behavior. However, the complexity of designing an ex-ante form of agreement to allocate responsibility and potential returns from the venture will be difficult. Similar to examples used previously, the terms of the agreement could be used by one agent to place the other agent in an awkward position.

**Table 6-12 Sources of Opportunism in Joint Venture: Organization #6**

| Source of Opportunism | | Joint Ventures |
|---|---|---|
| Uncertainty & Monitoring | Price | ✓ |
| | Quantity | ✓ |
| | Timing | ✓ |
| Asset Specificity | Site | ✓ |
| | Physical Asset | ✓ |
| | Human Capital | ✓ |
| | Dedicated | ✓ |
| Frequency of Transaction | | ✓ |
| Complexity of Exchange | | X |

✓ = market mechanism designed to handle this source of opportunism
X = market mechanism not designed to handle this form of opportunism

Much of the complexity of the agreement would be involved with the exchange of information. The agreement would have to detail what information must be shared and what is not. However, it is unlikely that the agreement could cover all contingencies, thus, there might be incentives to withhold information from a partner if the incentives are great enough.

### 6.11.2 Risks of Opportunism for Organization #6

Transactions, whether they are inside or outside the joint venture, hold incentives for opportunism. Each output from the barn / biodigester entity has differing

levels of opportunism. Although actual incentives for opportunism can not be quantified once they are identified, it is possible to weigh them against other options.

Given that the biodigester, barn and SaskPower are all part of a joint venture, monitoring costs will be incurred to ensure that all parties are providing accurate information and thus "pulling their own weight". Such monitoring could be costly to alleviate concerns of opportunism for both agents.

| | |
|---|---|
| Inherent: | In the event that GHG credits become significantly more valuable than the price contracted with SaskPower, then the HBF could threaten to exit the joint venture (and take their hog management skills with them) unless SaskPower is willing to give them a higher proportion of the revenues. |
| Circumstantial: | If hog prices were to drop, then the Barn could say that it must get more money to stay in business or else it will shut down the barn. This would effectively mean the end of the biodigester since the asset is immobile and the supply of manure would be cut off. SaskPower would have to decide to take legal action (which could hasten the HBF's demise) or, to succumb to the Barn's demand for more money. |

### 6.11.3 Transactions and the Possibility of Opportunism: Organization #6

The following table (Table 6.13) illustrates sources of opportunism for Organization #6, Hog barn and Biodigester as a Joint Venture for SaskPower. Each

transaction takes into account only the two agents and is not concerned with other agents on the supply chain.

**Table 6-13 Hog Barn and Biodigester as Joint Venture for SaskPower**

| | GHG Offsets | NPK Concentrate | Energy | Hogs | Manure |
|---|---|---|---|---|---|
| Specific Assets | open to opportunistic behavior | many potential buyers thus opportunism unlikely | open to opportunistic behavior | of low concern since only one producer and many buyers | open to opportunistic behavior |
| Frequency | open to opportunistic behavior | many potential buyers thus opportunism unlikely | open to opportunistic behavior | of low concern since only one producer and many buyers | open to opportunistic behavior |
| Uncertainty and Monitoring | open to opportunistic behavior | many potential buyers thus opportunism unlikely | open to opportunistic behavior | of low concern since only one producer and many buyers | open to opportunistic behavior |
| Complexity of Agreement | open to opportunistic behavior | many potential buyers thus opportunism unlikely | open to opportunistic behavior | of low concern since only one producer and many buyers | open to opportunistic behavior |

Manure: Both SaskPower and the HBF, as investors in the biodigester joint venture, have monetary disincentives to engage in behavior negatively affecting the flow of manure to the biodigester. Opportunism could be exacted via internal joint venture discrepancies similar to those previously mentioned.

GHG Offsets: The ownership of the GHG credits belongs to the joint venture. If, however, SaskPower is depending on this as a means of generating carbon credits then they will lock in on a contract price for these credits which is agreed upon ex-ante. If the value of

these credits increases then there is still the chance of opportunistic behavior on the part of their joint venture partner. This opportunism could again take the form of threats to withdraw from the joint venture by claiming financial problems.

Given a situation where GHG credits are valued significantly lower than that SaskPower predicted, then they might have an incentive to either under-invest or leave the joint venture. The former scenario would likely entail the HBF demanding compensation and perhaps taking legal action. This would be an expensive action and given the disproportionate size of the agents, time would be on SaskPower's side in a long adjudication.

As for a situation of under-investment by SaskPower, this would be far more difficult to prove within a legal environment and would perhaps lead to both agents "cutting their losses" and simply abandoning the joint venture.

NPK Concentrate: Given that the fertilizer market is characterized by a large number of buyers and sellers there is minimal likelihood of opportunistic behavior from outside the joint venture. However, opportunism could manifest itself in forms similar to that for GHG credits. For example, incentives to under-invest.

Energy: The primary use for energy from the biodigester is self-provision for the barn and biodigester. There is no room for opportunism

for this exchange. Residual energy would be destined for the SaskPower grid at an ex-ante determined price.

Where the potential for opportunism could arise is if the Hog Barn decides that it wishes to exit the joint venture and it no longer wants to self-produce its own electricity. Rather, it would prefer to purchase all of its electricity from the grid. This would be a significant departure from the original plans for the biodigesters. SaskPower would perhaps not want to provide electricity to the Hog Barn, even though it is an investor, since they are have lost a supply of GHG credits and it will increase demand on their existing generating capacity given their obligation to serve.

## 6.12 Conclusion

The purpose of this chapter has been to both present hypothetical organizations for biodigester development in Saskatchewan as well as to demonstrate the complexity of these hypothetical organizations. Six organizational forms have been examined. Each form has advantages and disadvantages relative to other forms. This has resulted in the assertion that the choice of an optimum organizational form is inconclusive. Rather, the choice of a specific form is dependent upon the transaction costs and uncertainty over opportunism that SaskPower is willing to face. Chapter seven will detail the role of dominance in the assertion of an inconclusive result and suggest a "least worst" solution to the problem.

# Chapter 7: Joint Venture between SaskPower and a Hog Barn Management Firm for the Management of Barn/Biodigester Operations

## 7.0 Introduction

This chapter begins with a discussion of organizational forms and their ability to eliminate or reduce opportunistic behavior (Section 7.1). Section 7.2 presents a binary decision making process (superior/inferior) to be used for determining an organizational form's effectiveness at limiting incentives for opportunism. The following section (section 7.3) presents the property of dominance and its role in determining a definitive "best" solution. Section 7.4 initiates the discussion of organizational forms #2, #3 and #5 Section 7.5 presents a discussion of Organizations #1 and #6. Section 7.6 looks at the importance of the manure flow for the choice of an organizational form. The remaining section (Section 7.7) concludes the chapter and introduces Chapter eight.

## 7.1 Choice of an Organizational Form

The decision as to which organizational form is optimal for biodigesters in

Saskatchewan involves a process of elimination by comparing transaction costs.

Although situations involving potential transaction costs can be discussed qualitatively, quantification for each given scenario is more difficult, particularly ex ante to their implementation.

## 7.2 Organizational Forms and Their Ability to Deal With Opportunism

Although no organizational form is capable of eliminating all sources of opportunism, each of the organizational forms examined in this thesis may be typified as superior or inferior to others based upon its ability to manage the risk of opportunism. This is illustrated in Table 7.1. Where the organizational form is considered superior relative to all other organizational forms for minimizing incentives for opportunism, it is marked **superior** while the alternative organizational forms are marked as inferior.

Table 7.1 Inferiority / Superiority of Organizational Forms

| | SaskPower Purchasing GHG credits from the Barn/biodigester<br>Organization #1 | Hog Barn Operates Biodigester as J.V. with SaskPower<br>Organization#2 | Third Party Manages Biodigester as a J.V. With SaskPower<br>Organization#3 | SaskPower Vertically Integrates Hog Production and Biodigester<br>Organization#4 | SaskPower Owns and Operates Biodigester<br>Organization#5 | Hog Barn and Biodigester as a J.V. for SaskPower<br>Organization#6 |
|---|---|---|---|---|---|---|
| GHG Offsets | inferior | inferior | inferior | **superior** | inferior | inferior |
| NPK Concentrate | inferior | inferior | inferior | **superior** | inferior | inferior |
| Energy | inferior | inferior | inferior | **superior** | inferior | inferior |
| Hogs | inferior | inferior | inferior | **superior** | inferior | inferior |
| Manure | inferior | inferior | inferior | **superior** | inferior | inferior |

### 7.3 Dominance

The option in which SaskPower vertically integrates both the Hog Barn and biodigester (Organization #4) may be superior to all others in terms of minimizing opportunism for all outputs and the manure input. However, this form is disregarded due to the organizational costs associated with SaskPower entering into the hog business since hog production is outside SaskPower's core competency as well as being outside their mandate as the provider of electricity for Saskatchewan. Hence, given a process of elimination the presentation in Table 7.2 excludes this option.

**Table 7.2 Dominance: Superiority / Inferiority of Organizational Forms**

| | SaskPower Purchasing GHG credits from the Barn/biodigester<br>Organization #1 | Hog Barn Operates Biodigester as J.V. with SaskPower<br>Organization#2 | Third Party Manages Biodigester as a J.V. With SaskPower<br>Organization#3 | SaskPower Owns and Operates Biodigester<br>Organization#5 | Hog Barn and Biodigester as a J.V. for SaskPower<br>Organization#6 |
|---|---|---|---|---|---|
| GHG Offsets | inferior | inferior | inferior | **superior** | inferior |
| NPK Concentrate | inferior | inferior | inferior | **superior** | inferior |
| Energy | inferior | inferior | inferior | **superior** | inferior |
| Hogs | **superior** | inferior | inferior | inferior | inferior |
| Manure | **superior** | inferior | inferior | inferior | inferior |

This thesis has relied on TCE form of analysis to identify the organizational form that mitigates the threat of opportunism for biodigester development. The ongoing growth of TCE and NIE has meant that terminology has had to be created simultaneously to effectively describe new economic properties.

Within the context of this thesis, dominance is defined as:

> In the absence of the ability to quantify the transaction costs associated with alternative organizational forms, they can only be judged using ordinal ranking over the entire range of exchanges where the threat of opportunism is prevalent.

For Example:

$y_m$ = set of m possible organizational forms

$x_n$ = set of n possible exchanges

$m \leq\geq n$: the comparison between m and n is indifferent to the number of organizational forms

$y_i$ = organizational form i

$x_i$ = exchange i

Given $y_m$ organizational forms that deal with $x_n$ exchanges, $m \leq\geq n$, an individual $y_i$ can be said to be dominant if, and only if, it is superior over each and every $x_i$ contained in $x_n$. If this condition does not hold, then no organizational form can be considered dominant.

Incentives for opportunism remain for all the organizational forms in Table 7.2. Since none are clearly superior, in that all parties to the agreement are protected from opportunism, one or more of the parties would have to accept the transaction costs associated with the opportunism not mitigated by that particular organizational form[35]. Thus, no organizational form is clearly dominant.

## 7.4 Discussion of Organizations #2, #3 and #5

Organizations #2, #3 and #5 are discussed at this point of the thesis due to the key role of the "flow of manure" transaction to these organizations. Organizations #1 and #6 will be discussed in Section 7.6.

### 7.4.1 Hog Barn Operates Biodigester as a J.V. with SPC: Organization #2

In the situation where the Hog Barn operates the biodigester as a joint venture with SaskPower it is inferior to the other organizational forms for all outputs and manure flow given the incentives to behave opportunistically. For GHG credits both parties have a vested interest in the success of the operation, but incentives to leverage the other partner in the joint venture still exist. For example, the barn could experience financial problems in hog production due to low hog prices. Although the barn has a financial stake in the success of the biodigester, this may not be enough to offset the barn's losses in the hog market, thus, giving the barn grounds for a real threat of closure.

[35] For example, organization #1 is inferior for energy transactions as the Barn/biodigester could shut down its operations and leave SaskPower with the costs of replacing that electricity supply to the grid.

Since information exchange between the Hog Barn and SaskPower may not stipulate the opening of either companies books on their private business dealings, SaskPower would have no way to verify if the threat is real or not. Since SaskPower would have made large investments into the biodigester, it would likely treat the threat of closure seriously, particularly if the market price for hogs has been low for an extended time.

Similar to the previous example, SaskPower could also act opportunistically by refusing to invest in the biodigester for the purpose of making improvements or undertaking maintenance. Potentially, this could be the case if the price of carbon credits turns out to be significantly less than what SaskPower had forecast prior to the ex-ante writing of the joint venture contract.

Thus, although this form of joint venture partnership may create a vested interest in the success of the joint venture, there is still room for either party to behave opportunistically if the benefits of opportunism are perceived to be greater than the benefits of maintaining the joint venture agreement.

### 7.4.2 Third Party Operates Biodigester as a J.V. with SPC: Organization #3

A joint venture arrangement for the management and operation of the biodigester offers advantages for SaskPower. The main advantage being mitigation of the uncertainty over investing in the biodigester itself as well as potentially benefiting from the expertise of a third party for the management of the biodigester. Similarly, the third party would benefit from the agreement due to its access, via the joint venture, to SaskPower's financial resources.

Incentives for opportunism exist in this system, firstly, from the Hog Barn to the biodigester. The flow of manure may be altered or adulterated by opportunistic or incompetent behavior on the part of the barn operations. For example, the barn may decide to shift its manure output to another buyer if the benefits are perceived as greater than any consequences of contract violation. The Hog Barn could also threaten shutdown due to any of the previously mentioned scenarios. Barn employees could also manifest incompetence through contamination of the manure supply. Within a transaction cost framework, this could be interpreted as the barn management being unwilling to assume the transaction costs associated with sufficiently close monitoring of barn employees to offset incompetence.

GHG offsets, energy or NPK concentrate could all be sources of opportunism if the third partner in the joint venture finds the entire enterprise unprofitable and threatens to withdraw from the agreement unless SaskPower subsidizes or buys out the third party's interest in the joint venture. Conversely, those three outputs could offer incentives for SaskPower to act opportunistically. Low prices for NPK concentrate energy, GHG offsets, or simple frustration in dealing with joint venture partners could promote the incentive for SaskPower to want to exit the joint venture.

### 7.4.3 SaskPower Owns and Operates the Biodigester: Organization #5

If SaskPower owns and operates the biodigester then there is no ambiguity regarding the outputs of the biodigester. All outputs from the biodigester are characterized by little incentive for opportunism. Thus, this form of organization is

superior to the others in many ways. Given GHG offsets, NPK concentrate, and energy SaskPower is not left to opportunism for these outputs. As for hogs, the Barn is the only party concerned with profitability of hogs and, as such, SaskPower has no concerns for management of this output.

Despite the apparent superiority of this organizational form, the incentive for opportunism via the flow of manure between biodigester and Barn may outweigh many of the apparent benefits.

For example, any action on the part of either the Hog Barn or SaskPower that put the flow of manure between Barn and biodigester at risk would threaten all the outputs from the operation. Thus, any organization that controls opportunism affecting the flow of manure may be preferred to all other forms of organization in the absence of a dominant form.

This can be explained by the rationalization that SaskPower may be benefiting from the acquiring of GHG credits from the biodigester but, if the manure flow is compromised then the ability to retain verifiable GHG credits from the biodigester is also compromised. This could be costly for SaskPower if they have to, in short order, find an alternative source of reliable credits to replace those of the biodigester. The flow of energy from the biodigester would be also compromised by irregularities in the nature and flow of manure from the Hog Barn.

Conversely, the Hog Barns manure management schemes could be compromised by the threat of closing down the biodigester. This entails that the barn must have some alternative manure management system that is sufficient for environmental regulations.

## 7.5 Remaining Organizational Forms, #1 and #6

The remaining two options #1 and #6, will be dealt with in sections 7.6.1 and 7.6.2 after a discussion on the importance of the manure flow exchange on the choice of organizational form.

## 7.6 The Importance of the Flow of Manure to the Choice of Organizational Form

Operation of the biodigester, regardless of ownership, is crucially dependent on the relationship between the barn and the biodigester due to the flow of manure. Thus, no matter what "giant" may be operating the biodigester, it is still "built on feet of clay". The assets required for operation of a biodigester are so specific that there is no viable alternative. Given that a Hog Barn's decision making process for maximizing profits will affect the nature of manure leaving the barn, any contractual arrangements that challenge the authority of the barn to make profit maximizing decisions for the production of hogs must entail clear and positive benefits to the barn. Such agreements would involve cash payments of substantive value to offset the difficulties associated with coordinating ones business activities with an unrelated activity (responsibility for providing manure to SaskPower quality and quantity standards). Even with these incentives, a prolonged period of low hog prices may not prevent the barn from wanting to shut down given such circumstances. This would leave the biodigester in a position where shut down would be inevitable as well. Subsequently, any energy, GHG credits, or NPK concentrate benefits would be negated.

Thus, the lesson of any agreement is that the biodigester will be viewed by the Hog Barn as a manure management scheme and as such must be subordinate to the price of hogs. Since hogs are the fundamental source of profitability for the Hog Barn, it is the primary factor determining the flow of manure.

It is the assertion of this thesis that the key exchange that determines the choice of organizational form is the flow of manure between barn and biodigester. Any disruption of this flow would affect the exchanges of all aforementioned outputs. Thus, the organizational forms which most effectively manage uncertainty over this flow are; Organization #1: SaskPower Purchasing GHG Credits from the Barn/biodigester as an Outside Party, and Organization #6: Hog Barn and Biodigester as a J.V. for SaskPower.

**Table 7.3 Relative Superiority / Inferiority**

| | SaskPower Purchasing GHG credits from the Barn/biodigester as an Outside party Organization #1 | Hog Barn and Biodigester as a J.V. for SaskPower Organization#6 |
|---|---|---|
| GHG Offsets | inferior | **superior** |
| NPK Concentrate | inferior | **superior** |
| Energy | inferior | **superior** |
| Hogs | **superior** | inferior |
| Manure | **superior** | inferior |

Within Table 7.3 SaskPower as a purchaser of credits is an inferior choice for the first three outputs, given the potential for contractual disagreement. The apparent inferiority of this option in terms of outputs is somewhat misleading due to the necessity of a secure manure flow for the success of the biodigester. Hence, all other sources of potential opportunism are subordinate to it.

### 7.6.1 SPC Purchases GHG Credits from Barn/Biodigester: Organization #1

This Organization is superior for both the sale of hogs and the exchange of manure between barn and biodigester. The sale of hogs would involve only the Hog Barn and the buyer and there would be no need to consult a joint venture partner. Similarly, the transfer of manure between the barn and the biodigester would be purely an internal exchange dependent upon management's profit maximizing decisions for the barn/biodigester as a single entity.

Difficulties for the exchange of GHG credits and electricity would be inferior to the joint venture given potential incentives for contractual opportunism. Although a contract may stipulate the terms and prices under which SaskPower retains GHG credits, SaskPower has no knowledge of the internal workings of the barn / biodigester operation. Many businesses contract without knowledge of the internal workings of their supplier because they generally do not involve situations given such specific investments. For example, if a carbon credit market were to emerge, SaskPower would then have the option to buy and sell credits via the prevailing exchange mechanism. To offset SaskPower's uncertainty over high prices for credits, they would want to "lock

into" a price for credits from the barn/biodigester. Since SaskPower does not have knowledge of the financial situation of the barn/biodigester, they are subject to the threat that if the price of hogs is so low that the barn/biodigester cannot operate profitably and must shut down or renegotiate the price of credits. If SaskPower is depending on these credits to ensure their production capability, then the threat of barn/biodigester shutdown would need to be taken seriously. The threat of shutdown by the barn/biodigester need not apply only to depressed hog prices. If the barn/biodigester also depends upon NPK concentrate for its profitability, a decline in the fertilizer market could also support a threat of shutdown unless a higher price is paid for credits. Similarly, an increase in the price for raw manure could be potentially be great enough for the barn/biodigester to face a legal battle over its GHG credit contract with SaskPower to gain the additional revenues from selling raw manure. These situations could all apply to the flow of energy as well. If SaskPower is depending on biodigesters as a source of energy, then the threat to shut down of any of the previously mentioned reasons could interfere with SaskPower's plans to depend on the barn/biodigesters as a source of energy.

The most important factor influencing the potential for this option is the incentive structure put in place for the establishment of biodigesters. At first glance, it may seem desirable for SaskPower to have several barn/biodigesters to source electricity and GHG credits. SaskPower would be in the position that, if they had contractual problems with some of the barn/biodigesters, the rest would be capable of "filling the gap." However, dealing with many barn/biodigester entities entails negotiating and maintaining many contracts. This could be prohibitively expensive. Also, since the

scenario of low hog prices being used as an excuse by the barns to renegotiate contracts, all barns would be facing low hog prices at the same time. Thus, it is likely that they would be voicing similar complaints to SaskPower over needing higher GHG or electricity prices to remain economically viable.

### 7.6.2 Hog barn and Biodigester as a J.V. for SPC and HBF: Organization #6

A comparison of the potential organizational forms has led to the suggestion that, in the absence of a dominant form, a joint venture is the organizational form that holds the lowest incentives for opportunism via affecting the quantity and quality of the manure flow between barn and biodigester. Although a joint venture has been suggested as the optimal form of organization, such agreements involve complex contracts that are prone to failure. Thus, the objective of this section is to outline the criterion for successful joint ventures and to propose a joint venture arrangement that could satisfy both SaskPower's demand for carbon credits and induce the development of biodigester equipped hog-barns in Saskatchewan.

An organizational form involving a Hog Barn and the biodigester operated as a joint venture between SaskPower and HBF provides a means to overcome the issue of manure flow. Although joint ventures are very complex agreements that are prone to failure, if they are "properly" constructed they offer the alternative most likely to allow both parties to share information and equitable profit sharing for such an operation. In turn, the barn/biodigester is viewed as one entity held by two owners. Consequently, a joint venture managerial structure would be necessary to facilitate decision making for

the barns. This would entail an additional layer of management (and investment) for SaskPower, but it may be the only means of ensuring that the results of the biodigester are in SaskPower's best interests and, presumably, in the HBF's best interests. A schematic of a joint venture is illustrated in Figure 7.1.

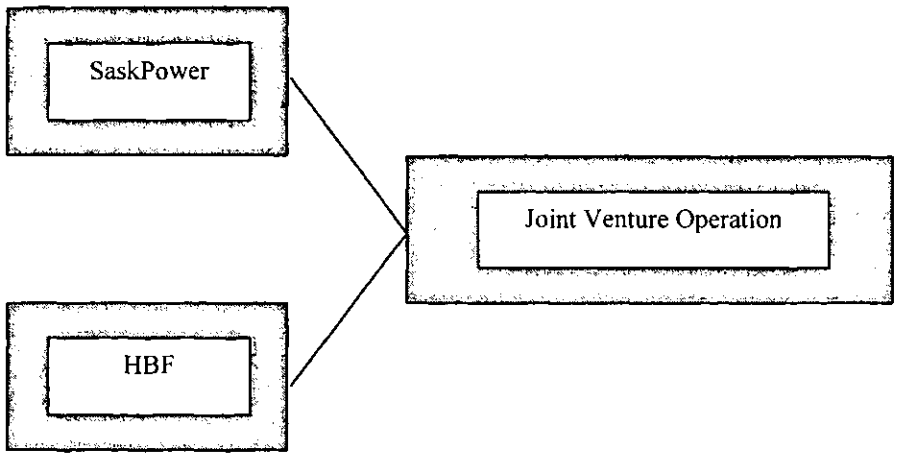



**Figure 7.1 SaskPower/Hog Barn Firm Joint venture**

The success of a joint venture between SaskPower and hog producers depends on the factors detailed in Section 5.10. The relevant factors:

- The relative size of the joint venture participants.
- The potential for divergence of interests within the joint venture resulting from "secret / proprietary" information that is necessarily shared for the success of the joint venture.

are described in the following section.

The first point is potentially a source of difficulty since it is unlikely that any joint venture partner with SaskPower is likely to be as large or have financial resources

comparable to SaskPower and, hence, there may be "difficulties arising from differences in size [that] force partners to confront power issues" (Lyels, 1987:80). Most of the Hog Barns in Saskatchewan are owned by local investors and operated by a management firm such as Big Sky or Quadra who hold an equity position in each operation (Khakbazan, 2000).

Such disparity of sizes necessitates a managerial form that presents an equitable business arrangement for the operation of the joint venture. This could be visualized as a specific entity composed of SaskPower managers and managers from the Hog Barn management company as a board of directors and management team for the joint venture barn/biodigester operations[36]. The barn/biodigester would be managed as an economic entity with a single profit function (see integration and institutionalization Section 5.10.1). Consequently the barn and biodigester "move together" as there is no divergence of interests given relative price changes in the given output sector (NPK, GHG, hogs, energy, manure).

The second point regarding a divergence of interests between members of the joint venture agreement is minimized since the barn and biodigester is a single financial entity. This is linked to the next point regarding the necessity of secret (proprietary) information that must be shared between the venture partners. This is particularly important since a key failing point for many joint ventures is unwillingness to share information, "the characteristics on effective inter-company relationships...Partners share information required to make the relationship work" (Moss-Kanter, 1994:105).

[36] It is unlikely that such an organization form comprising a board of directors could be replicated in the SaskPower head office. As it is a crown corporation, it would not likely be able to satisfy the political wishes of cabinet via the appointment of directors from a Hog Barn management company.

For the barn/biodigester entity, the nature of the information would be transparent and not subject to secretiveness. Prices for energy, manure, NPK concentrate, hogs, and other inputs (such as feed and labor) can be thought of as public information[37] and not subject to mistrust.

For management decisions (and to minimize mistrust), a board of directors, composed of executives from SaskPower and the HMF would be created to make decisions regarding the construction and operation of the barn/digesters. This board of directors would be created specifically (and only) for these barn/digester operations.

The selection of a board of directors would be from both SaskPower and the HMF to reflect the respective level of investment from each organization. This board would actively develop a management team hired and subordinate to the board. For example, each barn/digester would require a manager for the day to day tasks of operating the digester and Hog Barn. Similarly, experts would be employed to account for and report energy and carbon credits. This information would be available to the directors of the joint venture partners and not be distributed to outside persons.

## 7.7 Conclusion

This chapter has asserted that the "least worst" means by which to earn (GHG) credits from biodigesters is to have Hog Barn and the biodigester operations under one management. The determining factor for the choice of organization is the flow of manure between barn and biodigester and the organization that minimizes incentives for opportunism in this exchange is optimal.

[37] GHG credit prices may, in the future, be public information. However, this market does not yet exist.

A binary decision making process (inferior or superior) was used to delineate opportunistic tendencies of each form. However, in the absence of an absolutely dominant organizational form, the alternative form selected is that of joint venture between SaskPower and a HMF for offering the most amicable (transaction cost efficient) solution for the exchange of manure.

Chapter Eight is devoted to concluding the thesis, stating limitations to the study and proposing suggestions for further research.

# Chapter 8: Conclusions, Study Limitations and Recommendations

## 8.0 Summary of Conclusions

The purpose of this research was to suggest an organizational form for the development of biodigesters in Saskatchewan by using a transaction cost framework. The results of this study indicate that all organizational forms analyzed hold the potential for opportunistic rents to be exacted. No organizational form was found to be dominant. The nature of the exchange, however, affects the impact of the transaction costs. This made choosing an optimal organizational form a complex exercise. An organizational form designed to handle opportunism on one exchange would leave the agents exposed to opportunism within another exchange.

Previous transaction cost economic literature has examined scenarios involving only one exchange. This study of biodigesters involved several exchanges occurring simultaneously. Due to the complex nature of the problem, it is impossible to identify the dominant form.

Assessing this problem based on a TCE framework led to the suggestion of a joint venture agreement between SaskPower and a hog management firm to operate the

biodigester and the Barn. This is a "least worst" solution to the problem, in that, incentives for opportunism remain. Nevertheless, it is the most effective way to both encourage investment into biodigesters and, recalling the flow of manure has been asserted as the critical transaction, manage incentives for opportunism on the flow of manure between barn and biodigester.

SaskPower's interest in biodigesters is to manage uncertainty over future climate change legislation. Biodigesters have been suggested as a means to both earn GHG credits and offset demand on SaskPower's existing generation infrastructure. However, given that this technology is still unproven in a prairie climate, biodigesters themselves represent a form of technological uncertainty.

## 8.1 Study Limitations

- Throughout this thesis biodigesters have been assumed to be a proven technology for Saskatchewan
- IT is assumed that a carbon credit trading system to take advantage biodigesters will be realized in the near future.
- SaskPower was being motivated to look at biodigesters as a means of managing uncertainty over future climate change legislation
- Although there is detailed cost of biodigester development information for other areas of the world there is none for Saskatchewan. Thus another limitation arises from the unavailability of such information for costs and implementation of biodigesters.

- There may be potential benefits from biodigesters in Saskatchewan. However, uncertainty regarding the technology and means of industrial organization suggest that there may be easier means by which SaskPower can gain GHG credits and generate energy. These could include carbon sinks (forestation of lands) and cleaner means of electricity generation (natural gas).
- Transactions costs are generally not quantifiable, thus, it was impossible to establish definite numerical values for the options examined.

## 8.2 Recommendations for Further Research

This study examined organizational forms appropriate to provide incentives for developments of biodigester technology in Saskatchewan. At the time of writing this thesis there has not been sufficient research into the technical feasibility of biodigesters in Saskatchewan.

- The first recommendation of this study is that further research be performed to determine the technical feasibility of biodigesters in Saskatchewan.
- A second recommendation for further research is to weigh the costs and complexity of biodigesters relative to other options for electrical generation and attaining GHG credits.
- A third recommendation is that further research should be done into the multi-transaction approach for analyzing opportunism in other situations. Up until this thesis economists have used TCE strictly as a tool for analyzing situations involving single transactions and have not explored the dynamics of scenarios

involving multiple transactions taking place simultaneously. It is the assertion of this thesis that further research into this area could be a fruitful avenue to contribute to the future development and applicability of TCE. In particular, examining existing governance arrangements involving multiple simultaneous opportunities for hold-up may provide insights into how trade offs are made when dominance is not evident. Such an examination may also provide insights into how transactions costs are associated trade offs.

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