INCORPORATING SUSTAINABLE ENERGY DECISIONS IN AGRICULTURE

by

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DEDICATION PAGE

This thesis is dedicated to my family.

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ABSTRACT

Encouraging energy conservation (EC), energy efficiency (EE), and renewable energy (RE) implementation has been a fundamental policy tool for promoting sustainability in Nova Scotia (NS) over the past several years. However, on-farm decisions on technology options are based primarily on cost-benefit analysis and there is little consideration or support for determining the environmental and social considerations associated with energy choices. Decision-making that considers sustainability will often include social, economic, and environmental elements. Conceptual frameworks exist for incorporating sustainability considerations into decision-making. However, existing frameworks may not be appropriate for on-farm energy decision-making in NS as none link sustainability to energy decisions at the small enterprise level. The main goal of this research is to develop and test a framework that incorporates sustainability considerations into NS farm decision-making when selecting EC, EE and RE options to improve farm energy management. Mail surveys, as well as interviews and observations were used to gather information on NS farms and develop the Framework for Energy Sustainability in Agriculture (FESA). Case Studies were used to test FESA. Survey results showed that NS farmers have made significant reductions in energy use (32%) over the past decade through implementing various energy choices. A large majority of registered NS farmers implemented an EE, EC or RE upgrade on the farm between 2007 and 2012 (72.9%). While many farmers have had support (e.g. energy audits), energy upgrade opportunities remain. Also, as technology changes, new opportunities arise (e.g. LED lighting). FESA builds upon and increases the relevance of energy audits. FESA uses a management system approach to allow for continual improvement over time and consideration of environmental and social priorities, not just economics, when exploring energy upgrades. It provides a series of steps that can be followed by farmers, and energy professionals providing support services, for energy-related projects on the farm. The past energy policies and programs, and the many farmers who now exist as examples to others, may help carry the momentum forward and result in more implementation and future energy savings. Following FESA will help farmers make informed energy decisions that are integrated into whole farm management.

LIST OF ABBREVIATIONS USED

AD	Anaerobic Digester
COMFIT	Community Feed-In Tariff
CPI	Consumer Price Index
cwt	45.4kg (100 lb) of milk produced
EC	Energy Conservation
EE	Energy Efficiency
EGSPA	Environmental Goals and Sustainable Prosperity Act
ES	Energy Sustainability
ESR	Efficiency, Substitution, Redesign
FES	Farm Energy Specialist
FESA	Framework for Energy Sustainability in Agriculture
GE	Green Economy
GHG	Greenhouse Gas
GFR	Gross Farm Receipts
GSHP	Ground Source Heat Pump
hl	hecolitre
kWh	kilowatt hour
l	Litre
NAICS	North American Industry Classification System
NS	Nova Scotia
NSDA	Nova Scotia Department of Agriculture
NSFA	Nova Scotia Federation of Agriculture
n	number of responses
PDCA	Plan, Do, Check, Act
RE	Renewable Energy
VOIT	Values, Objectives, Indicators, and Targets

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CHAPTER 1 INTRODUCTION

The highest priority action areas to be addressed by global energy leaders and experts include energy efficiency (EE) and renewable energy (RE) (World Energy Council, 2015). In Canada, policy and program focus has included EE and RE implementation (Environment Canada, 2013; Natural Resources Canada's Office of Energy Efficiency, 2014). Canada is considered a world leader in RE production and has been identified as a world leader with respect to the rate of change in moving towards EE (Natural Resources Canada's Office of Energy Efficiency, 2014; International Energy Agency, 2013a).

Canada has seen steady growth in energy consumption, making energy conservation (EC) an important policy and program focus area (Natural Resources Canada, 2012). Diverse energy-related policies and programs have been used in Canada (International Energy Agency, 2013a; Natural Resources Canada's Office of Energy Efficiency, 2014). One example is ISO 50001. Canada was the first country in the world to adopt it as a national standard for energy management systems (International Energy Agency, 2013a; Natural Resources Canada, 2015).

The Government of Nova Scotia has developed legislation and policies to promote EC and RE. Examples include Nova Scotia’s Environmental Goals and Sustainable Prosperity Act (EGPSA), created in 2007, with 21 goals in the following areas: ecosystem protection, air emissions, renewable energy, water quality, contaminated sites, solid waste, sustainable purchasing, and energy-efficient buildings (Province of Nova Scotia, 2008). Another example is the Nova Scotia 2009 Energy Strategy with a vision for a sustainable energy future (Nova Scotia Department of Energy, 2009). These have resulted in more than 26% of total electricity produced in NS in 2015 from renewable sources compared to 10% in 2006 (Province of Nova Scotia, 2008; Province of Nova Scotia, 2017).

The agricultural sector has had focused programming to help achieve the EGSPA goals, including programs targeted at EC, EE, and RE (Agriculture and Agri-Food Canada, 2007; Nova Scotia Department of Agriculture, 2015b). Implementing EC, EE, and RE upgrades on the farm may have the direct benefit of reducing energy expenses, but there are many other non-energy benefits (International Energy Agency, 2013a). Some examples of non-energy benefits linked to agriculture may include improved animal welfare, safety, and water quality, and reduced waste (van Calker *et al.,* 2006; van Calker *et al.,* 2008). Making energy decisions on farms affects not only the consumption of energy (Dyer and Desjardins, 2006) but also the sustainability of the farms. Decision-making that acknowledges the importance of sustainability will often include consideration of three broad elements, also known as the three pillars: social, economic, and environmental (Klevas, Streimikiene and Kleviene, 2009; Buchholz *et al.,* 2009; Canadian International Development Agency, 2002; International Energy Agency, 2004; Martinsen and Krey, 2008; Brown and Huntington, 2008; Lipp *et al.,* 2005; Presidio School of Management, 2009). One way to encourage social, environmental, and economic improvements on the farm is through careful energy choices. These choices can help reduce GHG emissions and improve sustainability, or more specifically, energy sustainability (ES).

ES has been described as affordable and equitable access to efficiently produced and distributed energy, as well as efficient use of energy resources, a secure energy supply, and ensuring environmental sustainability (Canadian International Development Agency, 2002). The three pillars of sustainability are appropriately considered when evaluating energy systems (Buchholz *et al.,* 2009):

1) Environment: reducing ecological side effects of the energy supply chain and inefficient energy use (e.g. air pollution, GHG emissions, natural resource depletion)
2) Economic: reducing energy dependence and generating business and wealth (e.g. increasing local business development)
3) Social: improving human health, job creation, and stakeholder involvement in decision-making.

Energy audits are one tool used to evaluate energy options. This type of tool often provides the support needed for making on-farm decisions based on economic considerations. However, on-farm decisions on technology options are based primarily on monetary cost-benefit analysis. There is little consideration or support for determining the environmental and social considerations associated with energy choices (American Society of Agricultural and Biological Engineers, 2015). It is often much easier to focus on the financial aspects since farm operating costs associated with energy can be easily quantified. The costs and savings associated with best management practices and energy conservation choices can be quantified and communicated to the farmer (American Society of Agricultural and Biological Engineers, 2015). Searching for the optimal solution and incorporating only cost-benefit analysis may lead to project failure (Buchholz *et al.,* 2009). Although cost-benefit analysis is a fundamental component of energy management on the farm, environmental and social issues must also be part of the sustainability equation.

An analytical framework can help identify solutions that offer the greatest potential to assist in the transition towards sustainability (MacRae, Henning and Hill, 1993). Frameworks can help capture and visualize trade-offs among criteria and help move towards sustainability (Alkan Olsson *et al.,* 2009; MacDonald, 2005). Using a framework can help establish key values, assumptions, goals, and definitions. Conceptual frameworks exist for incorporating sustainability considerations into decision-making. However, these frameworks are designed with specific uses, definitions and a purpose in mind. For example, the ecological sustainability trigon (EST) is an example of a framework designed to evaluate environmental management scenarios for marine and estuarine ecosystems, under a sustainability lens (Marques *et al.,* 2009). Existing frameworks may not be appropriate for on-farm energy decision-making in NS. To rectify this issue, the conceptual foundations of ES as they apply to NS farming operations and energy choices on the farm must be defined. The definition of sustainability will shape the scope and content of the framework (MacRae, Henning and Hill, 1993). Application of a framework should help farmers navigate the complexities of sustainability and help transition towards more-sustainable energy choices. A practical and robust framework will provide a basic understanding of sustainability with the goal of reviewing economic, social, and environmental impacts, and promoting a logical assessment of those impacts and better priority-setting of options. It can encourage a more careful analysis of *all* the costs and benefits and therefore lead to more thoughtful decision-making.

1.1 RESEARCH GOALS AND OBJECTIVES

This research is focused on incorporating energy sustainability into NS farm decision-making when selecting energy conservation and generation options. The main goal of this study is to develop and test a framework to harmonize the elements of ES (economic, environment, and social) through the following objectives:

1) Identify the barriers and opportunities to implementing ES options given existing agriculture/energy policies.
2) Define the conceptual foundations of ES as they apply to NS farming operations and energy choices on the farm.
3) Develop an ES framework to harmonize the elements of environmental, economic, and social considerations for decision-making at the enterprise level.
4) Test the ES framework using in-depth analysis of specific farm enterprises.

1.2 METHODS

To increase the credibility and validity of the results, multiple methods have been used: interviews, a survey, observations of energy technologies used gained from farm visits, and case studies (Turner, Cardinal and Burton, 2017; Heesen, Bright and Zucker, 2016). Interviews were conducted to identify criteria used in on-farm energy decision-making and the survey was used to validate these criteria. The survey and farm visits were used to collect additional energy-related data including energy technologies implemented. The interviews, survey, and observations helped in the development of the framework. The case studies were used to validate the framework. The interview guide is included in Appendix A, the survey questions in Appendix B, and the case study interview guide in Appendix C.

1.3 CHAPTER LAYOUT

This thesis is made up of six chapters:

- Chapter 1 is the introduction.

- Chapter 2 is a published paper and presents results from the first section of the survey and compares them with results of a similar survey done in 2005. It examines the change in NS farm energy use from 2004 to 2011 to see whether reductions had occurred. It examines the effectiveness of existing energy policies and establishes a new baseline for future measurement.
- Chapter 3 is a paper that has been submitted for publication and presents the results from the second and third parts of the survey. It examines what EC, EE, and RE options have been implemented on NS farms between 2007 and 2012 and why these options were implemented. Additionally, the reasons for analysis and implementation of energy alternatives are evaluated through a sustainability lens. It also evaluates the extent to which NS farmers have considered social, environmental, and economic elements in their energy decisions to shed light on the importance of sustainability on the farm. Chapter 3 also presents information on decision-making criteria relevant to energy decisions on the farm for development of an ES framework.
- Chapter 4 is a transition paper that will not be submitted for publication and presents the results from farm visits, the fourth part of the survey, and additional information from the second and third parts of the survey not previously presented. It is used to bridge Chapters 3 and 5. It provides a summary of EC, EE, and RE interest and future opportunities for implementation of ES options. It presents the potential need for and use of an ES framework.
- Chapter 5 is a paper that has been submitted for publication and combines results from the interviews, surveys, observations of energy technologies used gained from farm visits, and case studies. It describes the ES framework and its development. It includes information synthesized from previous chapters that is utilized for framework development. It includes two case studies used to test the framework.
- Chapter 6 provides the main conclusions from Chapters 2 to 5.

CHAPTER 2 MEASURING ENERGY CONSERVATION ON NOVA SCOTIA (NS) FARMS: A 2004 TO 2011 COMPARISON

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2.1 ABSTRACT

Many jurisdictions, including Nova Scotia (NS), have implemented policies and programs around energy. The NS government has targeted energy efficiency and more renewable energy as two main policy areas. The NS Department of Agriculture has taken initiative to provide support to implement energy conservation, energy efficiency and renewable energy opportunities in recent years but have these programs and policies been effective? A baseline energy use survey was conducted in 2005 and responses from mail surveys in 2012 (n=273, 11.4% response rate) were used to measure the change in NS farm energy use data reported for 2004 and 2011. There have been significant reductions in energy use on NS farms. On average, NS farmers spent $8,790 on energy expenses in 2011 compared to $11,228 in 2004. Adjusting for inflation, this is a 32% decrease, despite energy commodity pricing increases beyond the inflation rate. This is likely due to a decrease in energy use and a shift from gasoline use to diesel use. By the end of 2012, 36.0% of NS farmers (more than 860) had received some level of support to evaluate their energy options. This includes 410 energy audits compared to only 36 by the end of 2005.

2.2 KEYWORDS

Energy conservation; Energy efficiency; Energy use; Nova Scotia Agriculture

2.3 NOMENCLATURE

cwt	100 lb of milk produced
CPI	Consumer Price Index
EGSPA	Environmental Goals and Sustainable Prosperity Act
GHG	Greenhouse Gas
GFR	Gross Farm Receipts
kWh	kilowatt hour
L	Litre
NAICS	North American Industry Classification System
NS	Nova Scotia
NSDA	Nova Scotia Department of Agriculture
NSFA	Nova Scotia Federation of Agriculture
n	number of responses

2.4 INTRODUCTION

Energy conservation, energy efficiency and renewable energy have been worldwide topics of discussion for years (World Commission on Environment and Development, 1987). There is a need to move away from fossil-fuel-based energy, reduce primary energy consumption while maintaining or increasing energy service, and use sustainable energy sources (Neves and Leal, 2010). Many jurisdictions have implemented policies and programs around energy (International Energy Agency, 2013b).

The Government of Nova Scotia has developed policies to promote energy conservation and renewable energy. These policies help reduce greenhouse gas (GHG) emissions and improve energy sustainability. Nova Scotia's Environmental Goals and Sustainable Prosperity Act (EGPSA) was created in 2007 with 21 goals in the following areas: ecosystem protection, air emissions, renewable energy, water quality, contaminated sites, solid waste, sustainable purchasing, and energy-efficient buildings (Province of Nova

Scotia, 2008). Nova Scotia's 2009 Energy Strategy vision is a sustainable energy future (Nova Scotia Department of Energy, 2009). The strategy lists increased energy efficiency and more renewable energy as two main policies for NS (Nova Scotia Department of Energy, 2009).

The NS Department of Agriculture has taken initiative to provide support to implement energy conservation, energy efficiency, and renewable energy opportunities on farms. Mitigating energy price increases through conservation methods can help NS farmers remain competitive. A Farm Energy Specialist extension position was available to NS farmers from 2007 to 2013. Also, under Growing Forward, a five-year program that ended in 2013, programs were created to target energy sustainability on farms (Agriculture and Agri-Food Canada, 2007). Growing Forward 2, which ends in 2018, has continued to support energy sustainability on farms (Nova Scotia Department of Agriculture, 2015b).

Have these programs and policies been effective? A baseline energy use survey was conducted in 2004 (Bailey, Gordon *et al.,* 2008). That study indicated that the agricultural community was keenly interested in energy conservation methods and renewable energy options (Bailey *et al.,* 2008; Bailey, Gordon *et al.,* 2008). However, have NS farmers implemented any improvements? Has there been any change? Or is the agricultural sector on a similar increasing energy use and GHG emissions trend as they had been on from 1990 to 2004 (Office of Energy Efficiency, 2006). Since 2004, there has been little follow-up and measurement of energy use in agriculture. Therefore, the purpose of this study was to measure the change in NS farm energy use from 2004 to 2011 in order to see whether reductions had occurred. This study was part of a larger survey designed to gather information on criteria used for on-farm energy decision-making.

2.5 METHOD

A mail-out survey of 2393 members of the Nova Scotia Federation of Agriculture (NSFA) was conducted in April 2012 and repeated in November 2012. The NSFA mail list was used as the sample frame. This is considered to be representative of the entire registered farm population since all registered farms are NSFA members (Nova Scotia Department of Agriculture, 2015a).

The survey was divided into five sections (A to E), each with a unique objective. The first section (A) was designed to gather demographic information such as farm type, farmer age, and income as well as basic information on energy use and energy concerns. The second section (B) gathered information on energy conservation and energy efficiency options used on the farm and the decision-making criteria used to choose these options. Questions were asked on what energy options were used on the farm, reasons for implementing or looking at alternatives, who influenced the decisions made, where respondents looked for information, and obstacles they may have encountered. The third section (C) was identical to section B except it was about alternative energy options and farmers were asked what energy source they had replaced, offset, or supplemented. The fourth section (D) was about future changes. Questions were asked about what energy conservation/efficiency and renewable energy options farmers were interested in using, what would influence their decisions to implement, when they planned on retiring, and their retirement plans for the farm. The fifth and final section (E) was a place for comments and ideas.

This paper presents the results from the first section (A) and compares them with results of a similar survey done in 2005 (Bailey, Gordon *et al.,* 2008).

2.5.1 Survey design

There were three demographic variables: farm type, farmer age, and farm size. Farmers were asked to indicate the percentage of their gross farm receipts by commodity out of 20 choices that best described their operation. This was done to mimic the farm registration process and allowed for the categorization of results based on commodity. Farmers were also asked to indicate their farm size based on nine interval categories of gross farm receipts (GFR).

Farmers were then asked to indicate the total amount of money spent by energy source during 2011. The challenge with this question was that some respondents included farmhouses, and others excluded them, so results may reflect residential and business expenses. Also, wood used as a heat source on the farm is often undervalued as an energy source.

Farmers were asked to rank their three main concerns with respect to energy usage including: cost to operate (energy/fuel bills), power reliability (power outages), availability of energy sources, cost to purchase new efficient equipment, equipment reliability, environmental concern, self-sufficiency, and other.

Farmers were asked if they had some level of support to evaluate their energy options including: an energy audit with report, farm visit by a professional, an equipment-specific review (e.g. lighting), and information provided by a professional.

The survey was pre-tested by six volunteers to make sure it was clear, unambiguous and could be completed in a relatively short time (30 minutes).

2.5.2 Survey sampling, administration and response

Surveys were mailed in April 2012 to all NSFA registered members. This was repeated in November 2012 due to a low return rate from the initial mailing.

All surveys included a cover letter and a stamped, self-addressed envelope. The cover letter explained the purpose of the survey and the risks and benefits of participation. It also included contact information and a submission deadline. A reminder notice was sent via mail in the NSFA newsletter and via email in the NSFA e-news within three weeks of the initial mailing.

All surveys were anonymous, since the names and addresses of respondents were not included in the survey returns. The initial survey was included in the mailing of the April 2012 NSFA Newsletter; the second survey was a stand-alone mail-out sent in November 2012.

For the initial mailing, a total of 118 surveys were returned during a 62-day time frame (4.9% return rate). 16 envelopes were returned with uncompleted or missing surveys; farmers were asked to return the survey blank if they were no longer farming. Therefore, the total number of usable surveys was 102. From the second mailing, a total of 250 surveys were returned during a 42-day time frame (10.5% return rate). If the farmer had previously completed the survey in the first mail out, or was no longer farming, the farmer was asked to indicate this and return the survey blank. 79 surveys were returned uncompleted: 35 were returned from those no longer farming, 32 had previously completed the survey, 11 were blank with a note that the survey did not apply, and one survey was blank. Therefore, the total number of usable surveys was 171. When combined, there were 273 usable surveys.

Response rate varied among farm types (Table 2.1), with an overall response rate of 11.4%. This was lower than expected based on a previous survey with a 32% response rate (Bailey, Gordon *et al.,* 2008). Typical mail questionnaires receive anywhere from 10% to 50% response rates (Weisberg, Krosnick and Bowen, 1996). The highest response rates were from maple, dairy and vegetable farmers; 22.2%, 21.6% and 19.6% respectively. The lowest response rates were from strawberry, fur and beef farmers; 0%, 6.9% and 7.7% respectively. It is worth noting that strawberry farms are the second smallest commodity group with only 20 registered farms while beef farms are the largest commodity group with 575 registered farms. Response rate also increased as farm size (GFR) increased (Table 2.1).

Table 2.1 Response Rates by Farm Type and Size

	2012 Farm Registration	**Returned Surveys**	**Response rate**
	Frequency	**Frequency[1]**	**%**
Apples	85	13	15.3
Beef	574	44	7.7
Blueberries	395	35	8.9
Chicken/Turkey/Eggs	116	14	12.1
Dairy	241	52	21.6
Fur	102	7	6.9
Grains/Forage	225	23	10.2
Grapes	46	6	13.0
Greenhouse	28	3	10.7
Hogs	16	2	12.5
Honey/Bees	25	4	16.0
Maple	27	6	22.2
Sheep	105	10	9.5
Strawberries	20	0	0.0
Vegetable	107	21	19.6
Other/Custom	190	29	15.3

	2012 Farm Registration	Returned Surveys	Response rate
	Frequency	Frequency[1]	%
Small <$25,000	1476	109	7.4
Medium $25,000 to $99,999	330	51	15.5
Large $100,000 to $499,999	287	51	17.8
Very Large $500,000+	209	50	23.9

[1]Although there were 273 usable surveys, only 269 farms indicated a farm type and 261 indicated a GFR.

2.5.3 Data analysis

For analysis, farm types were grouped using the North American Industry Classification System (NAICS) (Statistics Canada, 2012b). The categories included: (i) beef, (ii) dairy, (iii) hog, (iv) poultry/egg, (iv) sheep/goat, (v) other animal (honey, bees, fur, horse), (vi) oilseed and grain, (vii) vegetable, (viii) fruit and tree nut, (ix) greenhouse, nursery and floriculture production and (x) other crop farming (i.e., maple, hay, fruit and vegetable combination). This was done to allow for comparisons to data from Statistics Canada and to facilitate comparisons among groups. Also, different farm types have different energy needs (Brown and Elliott, 2005). Dairy and poultry farms are more energy- intensive relative to other farm types (Bailey, Gordon *et al.,* 2008). Also for analysis, farm sizes were grouped using GFR categories of small (<$25,000), medium ($25,000 to $99,999), large ($100,000 to $499,999) and very large ($500,000+).

Predictive Analytics Software (PASW V.17) and Minitab (V.16) were used to analyze the collected data (IBM Corp, 2013; Minitab Inc., 2013). The age distribution from the 2011 Census of Agriculture was compared to survey results on an overall basis to look for significant differences at a 0.05 significance level. To test this null hypothesis, the Chi-square Goodness-of-Fit test was used. The gross farm receipt distribution from the 2011 Census of Agriculture was also compared to survey results on an overall basis to look for significant differences at a 0.05 significance level. To test this null hypothesis, the Chi-square Goodness-of-Fit test was used. The Chi-square (χ^2) test was used to test for significant differences at the 0.05 significance level for categorical variables. Analysis of variance (ANOVA) and a follow-up Fisher test were used to test for significant differences at the 0.05 significance level for three or more categorical variables and a metric (numerical) variable (i.e. energy cost by farm type). Assumptions were checked for ANOVA tests: independence was assumed, the scale of measurement for the dependent variable was a scale or ratio, residuals were examined to verify constant variances, and normality was verified. A common-logarithm transformation was used to achieve normality of the error terms for energy expenses and results were back-transformed. One poultry farm's data on energy expenses were removed from the analysis because the total energy expense was 6% of the next lowest expense.

Historical energy price data (retail price including tax) for Halifax, NS, in 2011 was used to calculate fuel consumption: $1.073/L for oil, $1.262/L for diesel, and $1.254/L for gasoline (MJ Ervin and Associates Ltd., 2013). The 2004 and 2011 average price of propane for Truro, NS, ($1.147) was used because data for Halifax was not available for 2011 (MJ Ervin and Associates Ltd., 2013). NS farmers can apply for a refund of the provincial tax for gasoline, propane and diesel (Service Nova Scotia and Municipal Relations, 2011). This refund is not included in the pricing calculations. Electricity consumption was calculated assuming a rate of $0.135/kWh as a basis (the NS residential electrical rate in 2011 was 12.074¢/kWh, plus a charge of 0.466¢/kWh for energy efficiency programs, plus monthly usage fees) (Nova Scotia Power Inc., 2011).

The inflation rate is calculated to be 15.3% using Consumer Price Index (CPI) data for December 2004 and December 2011 for Nova Scotia (Statistics Canada, 2015b). The "all items" category was used for the calculation.

2.6 Results and Discussion

2.6.1 Validation

To verify that the results were representative of NS farms, the surveyed distribution of age ranges was compared to the 2011 Agricultural Census (Table 2.2). There were no significant differences using the Chi-Square Goodness-of-Fit test ($p = 0.745$). It should also be noted that the census data are from 2010 and the survey represents 2012 age data. It was not expected that a difference of two years would show different results.

Table 2.2 Comparison of 2011 Census and Survey Age Ranges

Age Range	Census[1]		Survey		difference
	Frequency	%	Frequency	%	%
Under 35 years	315	6.0	19	7.1	-1.1
35 to 54 years	2,085	39.9	108	40.3	-0.4
55 years and over	2,815	53.9	141	52.6	1.3
All ages	5,225		268		

[1] (Statistics Canada, 2012d)

There were significant differences when comparing the GFR distribution (Table 2.3) to the 2011 Agricultural Census (p=0). The survey had fewer farmers with GFRs <$10,000 than expected. The differences in GFR distribution may be associated with the use of NS Farm Registration for the sample frame. There were 1603 more farmers listed in the census than those registered. It was expected that there would be fewer registrants. Farm registration is voluntary and there is an annual fee (Nova Scotia Department of Agriculture, 2015a). Farms must be registered to access government agriculture programs but gross farm receipts must be >$10,000 (except for new registrants) to access many of the programs (Nova Scotia Department of Agriculture, 2015c). Therefore, fewer surveys would have been sent to farms in the <$10,000 category. Therefore, this category is underrepresented in the survey results. However, given that age distribution is representative, it is likely that the survey responses are representative of registered NS farmers, rather than all NS farmers.

Table 2.3 Census and Survey Gross Farm Receipt Distribution Comparison

Gross Farm Receipts	Census		Survey		difference
	Frequency	%	Frequency	%	%
<$10,000	1643	42.1	55	21.1	21.0
$10,000 to $24,999	799	20.5	54	20.7	-0.2
$25,000 to $49,999	418	10.7	26	10.0	0.7
$50,000 to $99,999	273	7.0	25	9.6	-2.6
$100,000 to $249,999	277	7.1	28	10.7	-3.6
$250,000 to $499,999	199	5.1	23	8.8	-3.7
$500,000 to $999,999	154	3.9	24	9.2	-5.3
$1,000,000 to $1,999,999	92	2.4	18	6.9	-4.5
$2,000,000 and over	50	1.3	8	3.1	-1.8
Total	3905		261		

Farm registration data are problematic for validation purposes in that annual dues are based on self-reported annual gross farm receipts. Registration fees vary with gross farm receipts; it is possible that farmers of all sizes understated their size during farm registration. For example, a farm with annual gross farm receipts of $25,000 can choose to pay $275 in registration fees for having gross farm receipts in the range of $25,000–$49,999, or instead, pay $140 and indicate a gross farm receipt of $10,000–$24,999 (Nova Scotia Department of Agriculture, 2015a). The survey is anonymous and there is no incentive to understate size. Therefore, only census data were used for validation.

2.6.2 Farm type and size

The NS agriculture industry is diverse with many different farm types and sizes (Table 2.4). For NS farms, the types of energy used, how much energy used, and where energy is used on the farm all vary by farm type and farm size (Bailey, Gordon *et al.,* 2008). There have been changes in farm sizes and types in Nova Scotia leading up to 2012 (Table 2.5). There are significantly more very small and very large farms (<$10,000 GFR and $1,000,000 to $1,999,999 GFR), and fewer medium to large farms ($50,000 to $499,999 GFR). There is also an increase in the number of farms by 2.9%, but a decrease in farm registration by approximately 10.2% (Mahoney, 2012; Crouse, 2007).

Table 2.4 Farm Type and Size (Survey results)

Farm Type	Small	Medium	Large	Very large	Totals
	<$25,000	$25,000 to $99,999	$100,000 to $499,999	$500,000+	Frequency
Beef	59%	32%	9%	0%	44
Dairy	2%	6%	40%	51%	47
Hog and pig	50%	0%	50%	0%	2
Poultry and egg	15%	8%	8%	69%	13
Sheep and goat	75%	8%	17%	0%	12
Other animal production	46%	18%	21%	14%	28
Oilseed and grain	33%	33%	0%	33%	3
Vegetable	57%	24%	5%	14%	21
Fruit	40%	22%	24%	15%	55
Greenhouse, nursery	33%	33%	33%	0%	6
Other crop	67%	23%	7%	3%	30
Total	42%	20%	20%	19%	261

Table 2.5 Comparison of Number of Farms by GFR for NS from the 2006 and 2011 Census

Gross farm Receipts	2005 [1]	2010[2]	difference	Pvalue[3]
<$10,000	1357	1643	21.1%	0
$10,000 to $24,999	835	799	-4.3%	0.1
$25,000 to $49,999	438	418	-4.6%	0.246
$50,000 to $99,999	317	273	-13.9%	0.026
$100,000 to $249,999	355	277	-22.0%	0
$250,000 to $499,999	236	199	-15.7%	0.034
$500,000 to $999,999	161	154	-4.3%	0.527
$1,000,000 to $1,999,999	64	92	43.8%	0.043
$2,000,000 and over	32	50	56.3%	0.075
Total	3795	3905	2.9%	

[1] (Statistics Canada, 2007), [2] (Statistics Canada, 2012a; Statistics Canada, 2013; Statistics Canada, 2012c), [3]Two proportion test

The dairy industry in Nova Scotia is one of the most thriving components of the NS agricultural industry. However, the number of dairy farms has decreased over the years. In 2005, there was an average of 63 dairy cows (not including replacement heifers and calves) on 346 farms in NS (Statistics Canada, 2012c). In 2010, there were 295 dairy farms in NS with an average of 74 dairy cows (Statistics Canada, 2012c). Milk production has remained fairly constant (Devanney and Reinhardt, 2011). This means that farm size increased; there are more, larger farms. It is interesting to note that there is no significant change in the percentage of registered NS farmers who are dairy farmers from 2006 (Table 2.6).

Table 2.6 Farm Type Distribution for 2006 and 2012 Farm Registration

Farm Type	2006	2012	difference	Pvalue
Beef	772	574	-25.6%	0.002
Dairy	310	241	-22.3%	0.205
Fruit & Vegetable	610	653	7.0%	0
Poultry	128	116	-9.4%	0.742
Fur	101	102	1.0%	0.281
Grains/Forages	184	225	22.3%	0
Sheep	78	105	34.6%	0.002
Hog	58	16	-72.4%	0
Other	423	270	-36.2%	0

(Mahoney, 2012; Crouse, 2007)

The number of registered beef farms has decreased by 25.6% since 2006 (Mahoney, 2012; Crouse, 2007). This results in a significant change in the percentage of registered farmers who are beef farmers from 2006. Other significant changes include an increase in fruit and vegetable farmers, grains and forage farmers, and sheep farmers. There has been a significant change from the decrease in hog farmers by 72.4%. The fur industry is the only industry that has seen little change in farm registration numbers since 2006. However, the census actually shows that there are more, smaller mink farms. There was a 38% increase in the number of mink farms between 2005 and 2010, and a 67.5% decrease in number of mink per farm (Statistics Canada, 2012c).

2.6.3 Energy usage and bills

In NS, after operating expenses were deducted, farmers made only 16 cents on every dollar earned in 2010 (Statistics Canada, 2012a). This is an improvement of 18% from 2004 but still 37% lower than 1990 (Statistics Canada, 2006a; Statistics Canada, 2006b). Since Gross Farm Receipts (GFR) only increased by 9.1% in 2010 (Statistics Canada, 2012a), farm operating expenses must have decreased. Energy pricing influences both direct and indirect energy costs on farms. So, despite the fact that energy prices have increased over the past seven years, ranging from 19% for propane to 59% for oil (Table 2.7), operating expenses have decreased.

Table 2.7 Energy Price comparison, 2004 and 2011

Energy Type	2004 Price[1]	2011 Price	difference
diesel	\$0.799/L[1]	\$1.262/L[2]	57.9%
electricity	\$0.10/kWh[1]	\$0.135/kWh[3]	35.0%
gasoline	\$0.872/L[1]	\$1.254/L[2]	44.8%
oil	\$0.676/L[1]	\$1.073/L[2]	58.7%
propane	\$0.964/L[2]	\$1.147/L[2]	19.0%

[1](Bailey, Gordon *et al.,* 2008), [2](MJ Ervin and Associates Ltd., 2013), [3](Nova Scotia Power Inc., 2011)

Transportation fuels have seen the greatest increase in pricing. Transportation fuels make up a large portion of overall energy usage on NS farms and are seeing a decreasing trend in usage. In 2004, transportation fuels made up 46.4% of NS farmer energy expenses compared to 38.8% in 2011 (Table 2.8).

Table 2.8 Energy costs by farm type

Farm Type	2011 [$]		diesel [%]		electricity [%]		gasoline [%]		oil [%]		propane [%]		wood [%]	
Beef	5,187	b	33.7	ab	17.3	d	20.8	a	2.0	*	1.3	*	2.4	*
Dairy	25,387	a	45.6	a	35.5	a	7.7	c	0.5	*	0.3	*	2.0	*
Poultry	31,445	a	11.5	c	36.3	abc	10.2	abc	14.0	*	17.9	*	0.0	*
Sheep/goat	4,205	b	9.2	c	24.6	abcd	10.8	abc	27.9	*	0.0	*	8.0	*
Other animals	6,601	b	12.8	c	31.9	abc	22.8	a	10.3	*	0.3	*	3.1	*
Fruit	8,193	b	27.9	b	20.1	bcd	17.7	ab	8.1	*	1.1	*	3.8	*
Vegetables	5,878	b	15.1	c	36.0	a	9.0	abc	4.6	*	3.6	*	7.3	*
Other Crops	5,475	b	29.3	b	22.5	acd	11.7	bc	8.3	*	1.7	*	11.5	*
Total energy	8,790		27.0		25.3		11.8		8.1		2.1		4.8	

For columns: Means followed by the same lower-case letter are not significantly different at the 5% level of significance using Fisher Method. *Normality of the error terms could not be achieved through transformation; therefore no statistical tests were conducted.

No NS farmers reported the use of natural gas. Natural gas is considered to be a competitive advantage for agriculture in other jurisdictions (Pretty-Straathof, 2013) but has only recently been made available in limited, mostly urban, areas of NS (Heritage Gas, 2014).

On average, NS farmers spent $8,790 on energy expenses in 2011. This is compared to $11,228 in 2004 (Bailey, Gordon *et al.,* 2008). Adjusting for inflation, this is a 32.1% reduction. This is despite the energy pricing increases beyond the inflation rate. This is likely due to a decrease in energy use and may be linked to energy efficiency programming since the majority of NS farmers (72.9%) have made an energy efficiency, energy conservation or renewable energy upgrade on the farm between 2007 and 2012. It is not likely due to a change in farm type or size. In section 2.6.2, it was mentioned that there are more very small and very large farms. While very small farms may decrease the average energy expenses, very large farms may increase it. Also, the average energy expenses would be unaffected by farm type since the largest energy consumers, dairy and poultry, have had no change in the percentage contribution to the NS average (Table 2.6). The change in energy expense from 2004 to 2011 varies by farm type (Table 2.9) and farm size (Table 2.10). It is interesting to note that medium farm expenses increased and large farm expenses only decreased slightly, whereas small and very large farm expenses decreased at much larger rates. This trend can be better explained by looking at the change in energy commodity by farm size from 2004 to 2011 (Figure 2.1). Shifting from one energy commodity to another can result in increased or decreased energy expenditures. It was assumed that farmers were using an energy commodity if they indicated they had an expense associated with that commodity. 35.2% fewer very large farms used oil in 2011 than in 2004. Oil had the largest cost increase compared to other energy commodities in the same time period. Also, more very large farms used wood (biomass) which may be considered a low-price commodity. The largest decreases in energy commodity use by farm size for electricity, gasoline and wood are seen with small farms (12.0%, 18.0% and 18.6% respectively). The largest increase in use of diesel was seen in small farms (10.9%).

Table 2.9 Energy usage by farm type in 2011 and percent change from 2004

Farm type	n	Total		diesel		electricity		gasoline	
		$	%*	L	%	kwh	%	L	%
Beef	39	5,187	-19.6	1,384	-25.7	6,631	-51.4	861	-49.6
Dairy	44	25,387	0.0	9,179	13.3	66,822	-20.0	1,565	-64.2
Poultry	11	31,445	-24.4	2,860	-10.7	84,610	-30.4	2,552	-15.9
Fruit	50	8,193	-35.0	1,813	34.2	12,218	-44.5	1,157	-44.3
Vegetables	19	5,878	-39.2	703	-0.2	15,659	-34.9	422	-60.5

*2004 total dollar amounts were adjusted for inflation to 2011 dollars.

Table 2.10 Energy expenses by farm size in 2011 and percent change from 2004

Farm Size	2011	2004*	Change
	$	$	%
Small (<$25,000)	3,063	4,948	-38.1
Medium ($25,000 to $99,999)	7,785	6,889	13.0
Large ($100,000 to $499,999)	15,851	16,440	-3.6
Very large ($500,000+)	45,661	59,271	-23.0

*Adjusted for inflation to 2011 dollars.

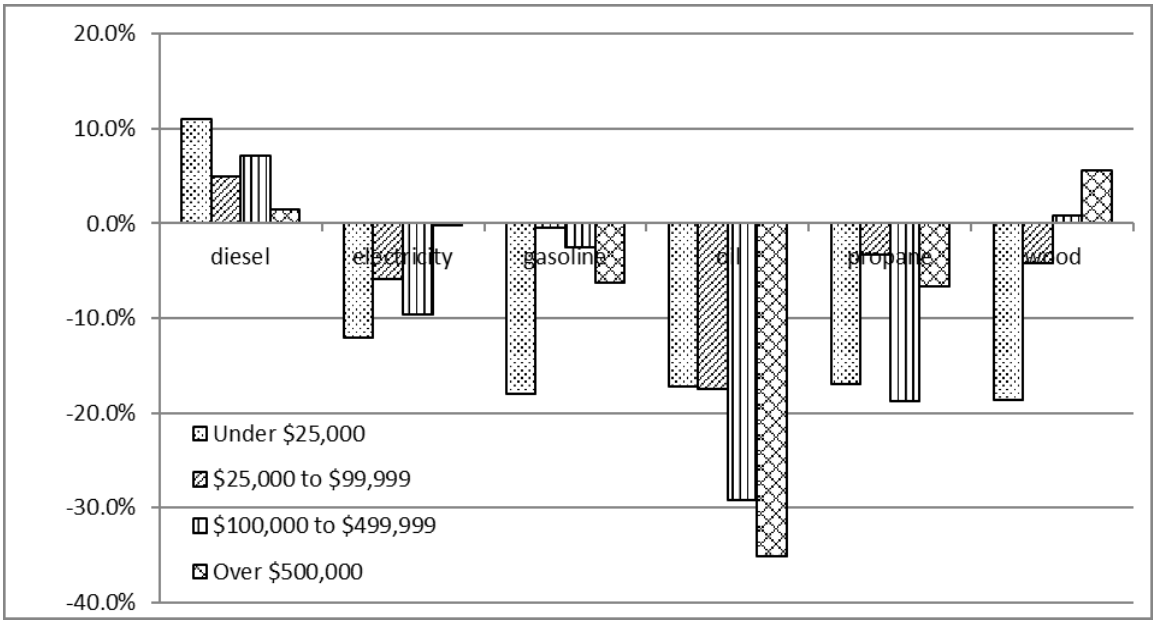

Figure 2.1 Change in proportion of farmers reporting an energy expense per energy commodity by farm size from 2004 to 2011

In 2011, overall, all energy commodities showed a decrease in the number of farms using them (on a per farm basis) except for diesel (Figure 2.2). More dairy and fruit farms are using diesel. Electricity is the only energy commodity in which all farms of a particular type use it; all poultry and dairy operations use electricity (Table 2.11). However, almost all dairy farms use diesel (97.7%). The highest percentage of farms using wood also belongs to dairy (38.6%). The highest percentages of farms using propane and oil belong to poultry farms (36.4% and 63.6% respectively).

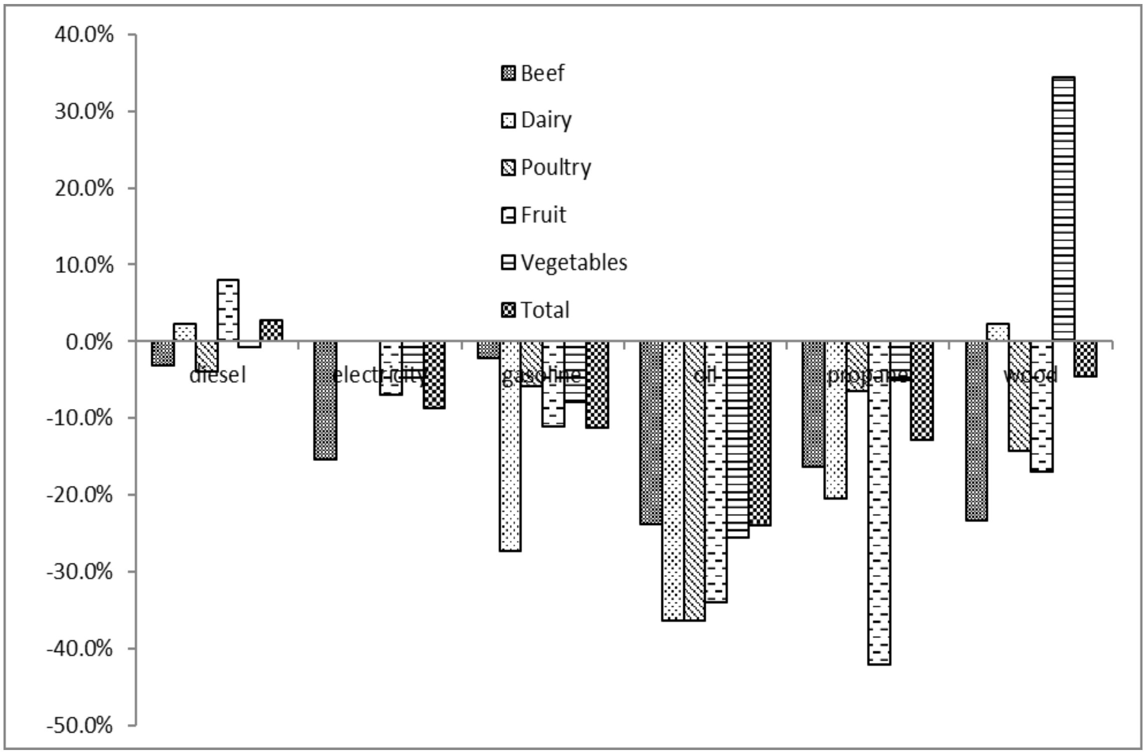

Figure 2.2 Change in proportion of farmers reporting an energy expense per energy commodity by farm type from 2004 to 2011

Table 2.11 Proportion of farmers reporting an energy expense by energy commodity for 2011

		n	diesel	electricity	gasoline	oil	propane	wood
Farm Type	Beef	39	89.7%	84.6%	87.2%	33.3%	5.1%	23.1%
	Dairy	44	97.7%	100.0%	63.6%	27.3%	6.8%	38.6%
	Poultry	11	81.8%	100.0%	72.7%	63.6%	36.4%	0.0%
	Fruit	50	88.0%	78.0%	74.0%	36.0%	8.0%	38.0%
	Vegetables	19	78.9%	89.5%	73.7%	36.8%	21.1%	36.8%
	Total	236	86.0%	86.9%	73.3%	38.1%	13.1%	36.0%
Farm Size	Under $25,000	95	78.9%	80.0%	67.4%	34.7%	8.4%	34.7%
	$25,000 to $99,999	48	87.5%	91.7%	77.1%	37.5%	16.7%	45.8%
	$100,000 to $499,999	48	89.6%	85.4%	75.0%	33.3%	6.3%	33.3%
	Over $500,000	45	95.6%	97.8%	80.0%	51.1%	26.7%	31.1%

2.6.3.1 DAIRY

In 2004, dairy farmers spent an average of $22,026 on energy compared to $25,387 in 2011 (Table 2.9). Adjusting for inflation, there is no change in energy expenses from

2004. However, there was an increase in farm size from 2004 to 2011, as well as increased energy costs beyond the rate of inflation, so farmers have reduced their energy use. Benchmarking shows a 57.2% reduction in electricity use per 100 lb of milk produced (cwt). NS dairy farms consumed 2.33 kWh/cwt of electricity in 2011, a reduction of 1.74 kWh/cwt from 2004 (Bailey, Gordon *et al.,* 2008). Compared to 2004, total electricity usage decreased by 20%, gasoline usage decreased by 64.2%, and diesel usage increased by 13.3%. This shows an overall improvement in efficiency on dairy farms: i.e., switching from gasoline to more-efficient diesel systems. As previously mentioned in section 3.3, slightly more dairy farms are using diesel (2.3%), and there is a large reduction in the number of dairy farms using gasoline (27.3%). Dairy farmers spend a significantly higher percentage of their energy expenses on diesel than did other farm types (except for beef). Electricity costs make up over a third of energy expenses on a dairy farm (35.5%). Energy efficiency programming has targeted decreased electrical consumption through lighting retrofit programs and rebates on equipment (Efficiency Nova Scotia Corporation, 2013b). Transportation fuels make up over half of the energy expenses (53.4%) on a dairy farm. Unfortunately, there has been little programming targeting transportation fuels, so switching to more-efficient diesel systems has likely been driven by cost. Low interest rates (Bank of Canada, 2013) may have also facilitated capital purchases, such as new tractors.

The 2011 Agricultural Census indicates that there was an increase in no-till farming in NS compared to the 2006 Census (Statistics Canada, 2012a). This, combined with a shift to diesel-based equipment, may help explain some of the decreases in transportation fuel use from 2004 to 2011. It is important to note that although NS dairy farmers have decreased their electricity consumption, they have seen an increase in their electricity bills because of rate increases and increases in farm sizes. Dairy farmers have the second highest energy bills of all farm types (second to poultry), so there may still be energy-efficiency opportunities on dairy farms.

2.6.3.2 Beef

In 2004, NS beef farmers spent an average of $5,597 on energy compared to $5,187 in 2011. Adjusting for inflation, this is a 19.6% reduction in energy costs. This is mostly attributed to a 51.4% reduction in electricity use. Although transportation fuel use was reduced by 37.1%, the average energy bill for beef farmers would have still increased with fuel reductions alone due to the 44% and 58% price increases associated with gasoline and diesel. Transportation fuels make up over half (54.5%) of the energy bills on a beef farm. The reasons why electricity has been reduced may be due to lighting retrofits since lighting is the top electrical user on a beef farm (Bailey, Gordon *et al.,* 2008). There has been a reduction in both the number of beef farms, and their size (Statistics Canada, 2012c). The reduction in farm size negatively affects energy benchmarking of NS beef farmers but the overall story is positive. In 2004, NS beef farmers used 402 kWh/cow (Bailey, Gordon *et al.,* 2008); in 2011 this decreased by 13.2% to 349 kWh/cow.

2.6.3.3 Poultry

In 2004, NS poultry farmers spent an average of $36,077 compared to $31,445 in 2011. Adjusting for inflation, this is a 24.4% decrease, mostly due to a reduction in oil use. Electricity, gasoline and diesel use all decreased but not at a higher rate than the price increase (30.4%, 15.9% and 10.7% respectively). In 2004, oil and propane made up 33.0% and 3.5% of energy expenses respectively. In 2011, oil and propane made up 14.0% and 17.9% respectively. Since there are only 11 poultry responses and the 2011 oil and propane expenses could not be transformed to induce normality of the error term, it is not possible to draw a statistical conclusion about reductions of these fuels. However, it does appear that there has been a shift away from oil; in 2004, 100% of poultry farmers indicated they used oil; in 2011 this dropped significantly to 63.6% ($p=0.026$). In some cases, NS poultry farmers have shifted from oil to propane for heating, but there may be some use of renewable energy technologies as well, such as ground source heat pump technology and agricultural biomass boilers (Farm Energy Nova Scotia, 2012a).

There was a 13.9% increase in the number of chicken/hen farms in NS between 2005 and 2010 (Statistics Canada, 2012c). The average size of these farms has not changed, so overall production has increased. There was a change for turkey farmers, with a 7.3% increase in the number of farms and a 7.4% increase in production per farm in 2010 compared to 2005 (Statistics Canada, 2012c). Therefore, overall poultry production increased and energy efficiency on poultry farms increased. Poultry farmers are using less energy to produce more meat and eggs. Poultry farmers also spend more on energy than any other farm type, so improved energy efficiency can have a significant financial benefit. Poultry farmers have decreased their electricity use by 30.4% since 2004. Unfortunately, this has not resulted in a decrease in electrical costs from 2004 levels due to increased electricity pricing. However, farmers have prevented their electrical bills from increasing dramatically and electrical bills make up over a third (36.3%) of their total energy costs.

2.6.3.4 FRUIT

In 2004, NS fruit farmers spent an average of $10,928 compared to $8,193 in 2011. Adjusted for inflation, this is a 35.0% decrease mostly from a reduction in electricity and gasoline use. Diesel use increased, thus showing a shift from gasoline to more-efficient diesel systems. Fruit farmers spent more on transportation fuels (45.6%) than other energy types, followed by electricity (20.1%). Blueberry farmers represented 56.0% of fruit respondents in 2011. Blueberry farmers spent $5,299 in 2011; adjusted for inflation, this is 32.0% less than 2004. They showed a decrease in electricity use (43.0% reduction), gasoline use (64.3% reduction) and diesel use (9.4% reduction) compared to 2004. The 2011 Agricultural Census indicates that blueberry production acreage increased from the 2006 Census in Nova Scotia (Statistics Canada, 2012a). The number of blueberry farms also increased but overall there was more productive area per farm (Statistics Canada, 2012a). This means that NS blueberry farmers have become more energy-efficient as they are using less energy on more area.

2.6.3.5 VEGETABLE

In 2004, NS vegetable farmers spent an average of $8,377 compared to $5,878 in 2011. Adjusted for inflation, this is a 39.2% decrease mostly from a reduction in electricity and gasoline use (reductions of 34.9% and 60.5% respectively). Nova Scotia reported an increase in field vegetable area (2%) in the 2011 Agricultural Census compared to the 2006 Census (Statistics Canada, 2012a). However, there was also a 2% increase in the number of vegetable farmers indicating there was no change in farm size of NS vegetable farms (Statistics Canada, 2012a). Overall, NS vegetable farmers have become more energy-efficient as they are using less energy on the same area. Vegetable farms are significantly different than fruit farms with respect to where they use energy. Transportation fuels make up only 24.1% of the total energy expenses for vegetable farms (versus 45.6% for fruit) and electricity expenses are the highest single energy expense on a vegetable farm (36.0% versus 20.1% for fruit). More vegetable farms used wood in 2011 compared to 2004 (34.4% more) and fewer vegetable farms used every other energy commodity (diesel, gasoline, electricity, propane and oil). This shift away from fossil fuel based energy sources may help explain some of the decrease in energy costs.

2.6.4 Energy concerns

The cost to operate has continued to be the primary concern for NS farmers with respect to energy usage. Table 2.12 shows that more than 90% of all NS farmers listed the cost to operate as a top three concern in 2005 and in 2012. A majority (67.8%) of farmers reported that the cost to operate was their number one concern with regard to energy usage on the farm. The cost of new equipment is the next greatest concern followed by the environment and self-sufficiency. Of those who picked operating cost as their number one concern, 46.1% had the cost of new equipment as their second concern.

Power reliability is not the concern that it has once been. The elevated concern over power reliability in 2005 was likely due to prolonged power outages from weather events in 2003 and 2004 (Cox, 2004; Emergency Management Office, 2003). The availability of energy has also decreased in importance since 2005 but may also be linked to these weather events.

Table 2.12 Top 3 energy concerns (n=262 unranked, n= 227 to 256 ranked)

Energy Related Concerns	**2005[1]** **Top 3 concern**	**2012** **Top 3 concern**	**1st**	**2nd**	**3rd**
Operating cost	96.4%	90.8%	67.8%	15.9%	5.7%
Cost of new equipment	57.6%	65.3%	10.6%	33.6%	17.9%
Environment	32.8%	30.5%	3.6%	8.7%	16.2%
Self-sufficiency	N/A	30.5%	3.7%	7.7%	14.6%
Equipment reliability	20.8%	29.8%	3.2%	9.3%	14.1%
Power reliability	50.3%	25.2%	4.4%	8.4%	8.8%
Availability of energy	30.1%	16.8%	4.7%	5.9%	5.7%
Other	1.9%	0.0%	0	0	0

[1] (Bailey, Gordon *et al.,* 2008)

2.6.5 Support for energy improvements

36% of respondents received some level of support to evaluate their energy options (n=272) (Table 2.13). An energy audit was the most common. Education on energy use and options is often used as programming to improve energy conservation implementation (Price and Hongyou, 2011).

Table 2.13 Percent of NS farmers using support for energy improvements (n=272)

	Type of Support	**% of NS Farmers**
Specific type of support	audit	17.3%
	equipment review	13.2%
	farm visit by a professional	15.1%
	information from a professional	11.4%
Some level of support	any one of the above	36.0%

In 2005, 64.4% of NS farmers were interested in an energy audit (Bailey, 2007) and only 1.4% had indicated that they had already had one. At the time the primary motivator for participation in an audit was cost savings (Bailey, 2007). In 2012, 17.3% of farmers had received an audit and 36.0% had received some level of support to evaluate their energy options; this represents over 410 audits and related support to over 860 farmers compared to just over 36 audits in 2005. As shown in section 2.6.3, many NS farmers have seen cost savings through energy reductions.

There were a number of initiatives after 2005 that would have impacted the support for energy improvements on farms in NS. In 2007, the NS Department of Agriculture created the Farm Energy Specialist position as the main contact for NS farmers for information on energy conservation and efficiency options, renewable energy options, energy audits, programs and funding (Bailey, 2010). The primary author of this paper occupied this position from 2007 to 2012. Funding for energy conservation and renewable energy improvements was made available under a federal, provincial, territorial initiative, Growing Forward, from 2007 to 2012 (Nova Scotia Federation of Agriculture, 2012a). In 2009, an Industry Research Chair position was filled in Farm Energy Conservation at the Nova Scotia Agricultural College (now Dalhousie Agricultural Campus) (Farm Focus, 2009). Conserve NS was created in 2006 with Efficiency NS taking over in 2011 as the provider of energy conservation and energy efficiency programming in NS (Efficiency Nova Scotia Corporation, 2013a; Muir, 2006; White, 2009). Efficiency NS provides incentives for various technologies (Efficiency Nova Scotia Corporation, 2013a). Agriculture specific technologies were added to the Business Energy Rebate program of Efficiency NS in 2012 (Efficiency Nova Scotia Corporation, 2015).

Support for energy improvements on farms may be especially important to communicate innovation and technology changes. The decision on the selection of technology choices or management changes to help reduce energy use can be complicated (Valipour, 2015).

2.7 Conclusion

There have been significant reductions in energy use on NS farms. On average, NS farmers spent $8,790 on energy expenses in 2011 compared to $11,228 in 2004. Adjusting for inflation, this is a 32.1% reduction. This is despite the energy pricing increases beyond the inflation rate. This is likely due to a decrease in energy use and a shift from gasoline use to diesel use. All farm types, except for dairy, saw decreases in total energy bills. Dairy farms did not see a decrease in total energy bills due to increased pricing and increased average farm size but they did decrease electricity usage by 20% and gasoline usage by 64.2%. Benchmarking shows a 57.2% reduction in electricity use per 100 lb of milk produced.

Although beef farmers saw the largest percentage reduction in electricity use (51.5%), compared to 2004, they also saw a reduction in farm size. Benchmarking shows a 13.2% decrease in electricity use per cow. Beef farmers decreased transportation fuel use but increased pricing resulted in increased fuel expenses.

Poultry farmers are using less energy to produce more meat and eggs. Poultry farmers reduced electricity use by 30.4%. Reductions in oil use and a shift to propane and renewable energy options have resulted in decreased overall average energy bills. Reductions in electrical use have prevented electrical bills from dramatically increasing. Fruit and vegetable farmers have become more energy efficient and are using less energy per acre. Fruit farmers reduced electricity use by 43.0% and they are shifting from gasoline to diesel use. Vegetable farmers have decreased electricity use by 34.9% and are shifting away from fossil fuel based energy sources and more vegetable farmers are using wood.

Energy efficiency support likely played a role in energy savings, especially electricity savings, as most programming was targeted at electrical use. By the end of 2012, 36.0% of NS farmers (more than 860) had received some level of support to evaluate their energy options. This includes 410 energy audits compared to only 36 by the end of 2005. Programming included resource support of money and expertise: government funding, dedicated government staff support specific to the agricultural industry, dedicated academic research specific to the agricultural industry, the creation of an energy conservation and efficiency agency, and incentives targeted at agricultural technologies. Despite the savings seen across the industry, the cost to operate continues to be the primary concern for NS farmers with respect to energy usage. Most energy related programing has focused on electricity. While opportunities likely still remain for electrical conservation and efficiencies, fossil fuels for transportation and heating may be a target area for future energy conservation, efficiency and renewable energy programming.

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CHAPTER 3 ENERGY CONSERVATION, ENERGY EFFICIENCY AND RENEWABLE ENERGY IMPLEMENTATION ON NOVA SCOTIA FARMS: WHAT AND WHY BETWEEN 2007 AND 2012

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In Preparation

3.1 ABSTRACT

Encouraging energy conservation (EC), energy efficiency (EE) and renewable energy (RE) implementation has been a fundamental policy tool for promoting sustainability in Nova Scotia (NS) over the past several years. The agricultural sector has focused programming to achieve that goal. There have been positive results and NS farmers have made significant reductions in energy use over the past decade through implementing various energy choices. Mail surveys in 2012 (n=273, 11.4% response rate) were used to gather information on EC/EE and RE options used on the farm in NS and the decision-making criteria used to implement these options. A large majority of registered NS farmers implemented an EE/EC or RE upgrade on the farm between 2007 and 2012 (72.9%). These upgrades resulted in large energy reductions on NS farms. More farmers implemented EE/EC upgrades than RE (68.9% versus 28.2%). There has been a large increase in the implementation of RE since 2005, when less than 10% of farms used RE options at that time. Efficient lighting was the most implemented energy upgrade with 51.2% of registered NS farmers completing a lighting upgrade between 2007 and 2012. NS farmers who received support were more likely to implement an EE/EC or RE upgrade.

3.2 KEYWORDS

Energy conservation; Energy efficiency; Renewable energy; Nova Scotia Agriculture; Decision-making

3.3 INTRODUCTION

Energy efficiency (EE) and renewable energy (RE) have been flagged as the highest priority action areas to be addressed by global energy leaders and experts (World Energy Council, 2015). EE and RE implementation have been important policy and program areas in Canada (Environment Canada, 2013; Natural Resources Canada's Office of Energy Efficiency, 2014). Canada is considered a world leader in RE production (Natural Resources Canada's Office of Energy Efficiency, 2014). Canada has also been identified as a world leader with respect to the rate of change in moving towards EE (International Energy Agency, 2013a).

There are many different energy related policies and programs used in Canada (International Energy Agency, 2013a; Natural Resources Canada's Office of Energy Efficiency, 2014). One example is ISO 50001, Canada was the first country in the world to adopt ISO 50001 as a national standard for energy management systems (International Energy Agency, 2013a; Natural Resources Canada, 2015). Energy conservation (EC) is also an important policy and program focus area, despite the steady growth in energy consumption overall (Natural Resources Canada, 2012).

The agricultural sector was the only sector in Canada to see a decrease in energy use between 1990 and 2009 (6% decrease compared to an overall sector wide increase of 23%) (Natural Resources Canada, 2012). How did this happen? Unfortunately, there is a lack of current agricultural energy data across Canada (Dyer, Desjardins and McConkey,2014). The most comprehensive information source on farm energy use in Canada is the 1996 Farm Energy Use Survey (FEUS) (Dyer, Desjardins and McConkey,2014; Khakbazan, 2000). Although recent census data on farm operating expenses can be used to some degree, it is limited in the ability to evaluate detailed energy use by type. Using farm expense data rather than detailed energy use data may result in incorrect conclusions about energy dependence and energy use relationships (Dyer, Desjardins and McConkey,2014). Farm energy surveys can provide essential information (Dyer, Desjardins and McConkey,2014). This was the motivation behind two farm energy surveys conducted in Nova Scotia (NS): a baseline in 2005 and a follow-up in 2012 (Bailey *et al.,* 2016; Bailey, Gordon *et al.,* 2008).

Encouraging EC, EE and RE implementation has been a fundamental policy tool for promoting sustainability in NS over the past several years (Nova Scotia Department of Energy, 2009). The agricultural sector has focused programming to achieve that goal (Agriculture and Agri-Food Canada, 2007; Nova Scotia Department of Agriculture, 2015b). There have been significant energy reductions on NS farms over the past decade following a 20-year trend of insignificant EE improvements on farms across Canada (Bailey *et al.,* 2016; Dyer and Desjardins, 2006). This is important to help the NS agricultural industry remain competitive (Natural Resources Canada, 2014). Overall farm expenses (including utilities) in NS have had an increasing trend and the cost to operate has been the primary energy concern for NS farmers over the past decade (Bailey *et al.,* 2016; Statistics Canada, 2015a; Bailey *et al.,* 2008). It has only been in the past few years that the ratio of operating expenses to revenue has seen a decrease, indicating an increase in profitability for NS farmers (Statistics Canada, 2015a). However, as previously mentioned, using farm expenditure data rather than more detailed energy use data can result in incorrect energy trend conclusions (World Energy Council, 2015). To draw conclusions about what is really going on with respect to energy use in agriculture, it is necessary to use more detailed data. So, how are NS farmers achieving energy reductions? Can energy reductions be linked to implementation of energy choices? Have NS farmers gone from being merely interested in EE, EC and RE to actual implementation (Bailey *et al.,* 2008)? Additionally, what changes have been made and have NS farmers used the available programming?

Beyond understanding what energy changes have been made on farms in NS, the reasons behind those decisions are also important. Decision-making on farms affects not only the consumption of energy (Dyer and Desjardins, 2006) but also the sustainability of these farms and even sustainability beyond the farm gate. Energy technologies themselves are not sustainable or unsustainable, but may contribute to sustainability (Grunwald and Rosch, 2011). Implementing EC, EE and RE upgrades on the farm may have the direct benefit of reducing energy expenses, but there are many other non-energy benefits (International Energy Agency, 2013a). Some examples of non-energy benefits linked to agriculture may include improved animal welfare, safety, and water quality and reduced waste (van Calker *et al.,* 2006; van Calker *et al.,* 2008). Implementing EC, EE and RE upgrades should not only be a financial issue. When promoting sustainability, consideration should be given to the three foundational elements that are also known as the three pillars: social, economic, and environmental (Klevas, Streimikiene and Kleviene, 2009; Buchholz *et al.,* 2009; Canadian International Development Agency, 2002; International Energy Agency, 2004; Martinsen and Krey, 2008; Lipp *et al.,* 2005; Presidio School of Management, 2009). A review of bioelectric projects in Uganda found that when the three components of sustainability were incorporated into decision analysis, social criteria, not costs, were the main factor in project viability (Buchholz *et al.,* 2009). Evaluating the extent to which NS farmers have considered social, environmental and economic elements in their energy decisions may shed some light on the importance of sustainability on the farm.

This is timely given the direction many governments are making to move towards a Green Economy (GE) (United Nations Department of Economic and Social Affairs, 2016). Internationally, the green economy has gained significant attention following the global financial crisis of 2008-2009 (Mundaca *et al.,* 2016; Division for Sustainable Development, 2012). The Green Economy definition varies, but the NS government references the following definition in their Greener Economy Strategy proposed in 2014 (Nova Scotia Department of Environment, 2014): "The aggregation of consumer, corporate and policy efforts to increase operational efficiency and minimize environmental impact while fostering economic growth, diversification and competition (TD Economics, 2013)." The NS government suggests the green economy provides an opportunity to maximize economic benefits while transitioning towards environmental sustainability (Nova Scotia Department of Environment, 2014). It may be an attempt to rebrand the concept of sustainability. The GE concept aims to merge environmental, social and economic objectives (Pahle, Pachauri and Steinbacher, 2016). Regardless, sustainable energy and the green economy can have economic, environmental and social benefits (Pahle, Pachauri and Steinbacher, 2016; Ringel *et al.,* 2016).

This paper looks at what EC, EE and RE options have been implemented on NS farms between 2007 and 2012 and why these options were implemented. Additionally, the reasons for analysis and implementation of alternatives are evaluated through a sustainability lens.

3.4 METHOD

A mail survey of 2393 members of the Nova Scotia Federation of Agriculture (NSFA) was conducted in April 2012 and repeated the following November. The sample frame was the NSFA mail list and is considered to be representative of the entire registered farm population since they are also NSFA members (Nova Scotia Department of Agriculture, 2015a). Farm registration is voluntary and there is an annual fee (Nova Scotia Department of Agriculture, 2015a). Farms must be registered to access government agricultural programs and additionally, annual gross farm receipts (GFR) must be >$10,000 (except for new registrants) to access many of these programs (Nova Scotia Department of Agriculture, 2015b). Compared to the census, there are fewer farms in the <$10,000 annual GFR category that are registered (Statistics Canada, 2012d). Although the sample frame captures all registered farms, it does not capture all farms in NS.

The survey was designed to collect information on criteria used for on-farm energy decision-making and to provide evidence for the validity of the decision-making criteria identified in previous interviews. Interviews were conducted between November 2011 and January 2012. The interviews were designed to collect information on criteria used for on-farm energy decision-making. The interview questions also allowed for the identification of barriers and opportunities to implementing energy sustainability options given existing agriculture/energy policies. There were two populations for the interviews:

NS farmers who had implemented an energy improvement in the three years prior to the interview, and North American energy professionals with experience conducting on-farm energy audits. There were ten interviews per population. The sampling was purposive and individuals were identified by the lead author, who serves as the Farm Energy Specialist with the NS Department of Agriculture. The primary author of this paper occupied this position from 2007 to 2012. The sample population was selected to allow for input from those who inform energy decisions and those who make them. The sample size was determined to ensure the capturing of views associated with a range of business types and sizes. The interviews identified the following information used in the survey design: reasons for implementing EE/EC and RE, reasons for considering alternatives when selecting EE/EC and RE upgrades, types of support used for energy decisions, information delivery mechanisms, and obstacles encountered. Using multiple methods such as surveys and interviews (methodological triangulation) is important to increase the credibility and validity of the results.

The survey was divided into five sections each with a unique objective. The first section was designed to gather demographic information such as farm type, farmer age and farm income as well as basic information on energy use and concerns. The second section was designed to gather information on EC and EE options used on the farm and the decision-making criteria used for selection of options. Questions were asked on types of energy options used on the farm, reasons for considering alternatives, if anyone influenced the decision, where the respondents went for information, and obstacles encountered. The third section was identical to the second except it was about RE options and farmers were asked what energy source they replaced, offset or supplemented. The fourth section was about future changes. Questions were asked about the EC/EE and RE options farmers were interested in, decision influencers, and retirement plans for the farm. The fifth section was a space for comments and ideas.

This paper presents the results from the second and third sections.

3.4.1 Survey design

The survey included farm type, farmer age, and farm size as demographic variables. Farmers were asked to indicate their age based on three interval categories of age range. Additionally, they were asked if they had done any new construction or renovation on the farm in the past five years.

Farmers were asked to indicate the EC and EE options they had used on the farm in the past five years and were given a list of 14 choices. The intent of this question was to highlight upgrades done over a five-year period. They were asked to provide a brief description of one option and select their reasons for making that upgrade from a list of 24 options. They were also asked to indicate their main reason. Farmers were asked the following additional questions around EE/EC implementation:

- Had they considered other technologies? If so, why did they choose that technology over the alternatives? They were given a list of 33 reasons to pick from and asked to indicate all the reasons and highlight the main reason.
- Had anyone influenced their decisions? If so, whom? They were given a list of 18 potential influencers. Farmers were asked about which methods of information delivery they used to get information on their upgrade and were given a list of 12 options to pick from.
- Had they encountered any problems or obstacles when making the upgrade? If so, they could select their problem or obstacle from a list of 12 options.

Farmers were asked the same questions as above for RE options. Additionally, farmers were asked to indicate the energy source that was replaced, offset, or supplemented if they replaced existing equipment when making the RE upgrade.

The survey was pre-tested by six volunteers to make sure it could be completed in a relatively short period of time (30 min) and was clear and unambiguous.

3.4.2 Survey sampling, administration and response

All surveys included a cover letter and a stamped self-addressed envelope. The cover letter explained the survey purpose, risks and benefits of participation, contact information, and a submission deadline. All surveys were anonymous, since the names and addresses were not included in the responses. Surveys were mailed in April 2012 to all NSFA members and repeated in November 2012 due to a low return rate from the initial mailing. The initial survey was included in the mailing of the NSFA Newsletter; the second survey was a stand-alone mail-out. A reminder notice was sent in the NSFA newsletter and NSFA e-news within three weeks of the initial mailing.

A total of 118 surveys (102 usable) were returned during a 62-day time frame (4.9% return rate) for the initial mailing. From, the second mailing, a total of 250 surveys (171 usable) were returned during a 42-day time frame (10.5% return rate). When combined, there were a total of 273 usable surveys. The farmer was asked to return the survey blank if s/he had previously completed the survey in the first mail out or was no longer farming.

The overall response rate was 11.4%. This was lower than expected based on a previous survey in 2005 with a 32% response rate (Bailey, Gordon *et al.,* 2008); however, typical mail questionnaires receive anywhere from 10% to 50% response rates (Weisberg, Krosnick and Bowen, 1996).

3.4.3 Data analysis

Minitab (V.17) and Predictive Analytics Software (PASW V.17) and were used to analyze the collected data (IBM Corp, 2013; Minitab Inc., 2013). The 2011 Census of Agriculture was compared to survey results for age distribution to look for significant differences at a 0.05 significance level. The Chi-square Goodness-of-Fit test was use to test this null hypothesis. The 2011 Census of Agriculture was also compared to survey results for gross farm receipt distribution to look for significant differences at a 0.05 significance level. The Chi-square Goodness-of-Fit test was used to test this null hypothesis. Confidence intervals (CI) were calculated at the 95% confidence level. The two-proportion test was used at the 0.05 significance level (Moore and McCabe, 2006).

Reasons for implementing EE/EC and RE, as well as reasons for considering one technology over another for EE/EC and RE, were categorized for analysis. To facilitate an even comparison between categories, weightings were allotted to each category. The resulting percentages were normalized. For example, the reasons for considering one technology over another were divided into four categories. Ideally, respondents would have an equal opportunity to select reasons from each category (25% of all the reasons that could be selected should be from each category). However, only monetary reasons had 25% of the reasons that could be selected, and it received a weighting of 1. Environment, social and other received weighting of 2, 0.6 and 1.2 respectively. The weightings for the categories for considering one technology over another for EE/EC and RE were 1.65, 3.30, 0.47, 0.73, and 1.65 for monetary, environment, social, technical, and other, respectively.

Categories of decision-making influencers were also weighted, and percentages normalized to facilitate an even comparison between categories (paid service provider, unpaid service provider and family/friend/peer: 0.935, 0.623, and 2.805 respectively).

3.5 Results And Discussion

3.5.1 Validation

The surveyed distribution of age ranges was compared to the 2011 Agricultural Census to verify that the results were representative of NS farms and no significant differences were found using the Chi-Square Goodness-of-Fit test ($p = 0.745$) (Statistics Canada, 2012d). There were significant differences when comparing the 2011 Agricultural Census to the Gross Farm Receipt (GFR) distribution ($p=0$). The survey captured fewer farmers with GFRs <$10,000 than expected. The differences in GFR distribution may be associated with the use of NS Farm Registration for the sample frame. Since there were 1603 more farmers listed in the census than those registered, this category is underrepresented in the survey results. However, given that age distribution is representative, it is likely that the survey responses are representative of registered NS farmers, rather than all NS farmers.

3.5.2 Energy options used on the farm

The average NS farmer spent 32.1% less on energy in 2011 than they did in 2004 (Bailey *et al.,* 2016). These large energy reductions and savings on energy expenses on NS farms are likely associated with energy upgrades (Bailey *et al.,* 2016). The majority of NS farmers (72.9% ± 5.0%) have made an EE/EC or a RE upgrade on the farm between 2007 and 2012. EC and EE upgrades are more popular than RE upgrades. 68.9% ± 5.2% of NS farmers made an EE/EC upgrade on the farm between 2007 and 2012 compared to 28.2% ± 5.0% of NS farmers who made a RE upgrade (including wood) in the same time period. This is not unexpected as EE/EC upgrades are often cheaper to implement than RE upgrades and EE/EC upgrades should be done before considering RE upgrades, in most cases, to prevent over sizing of equipment. Additionally, funding and support programming available for NS farmers at the time favored larger cost recovery for EE/EC compared to RE. This will be discussed further.

Efficient lighting upgrades were the most frequently implemented EE/EC option with 51.2% completing an upgrade between 2007 and 2012 (Table 3.1). This is not surprising given the targeted efficient lighting programming in NS at the time, for example (Bailey, 2010; MacPherson, 2009):

1. Farmers (and other businesses) could have an EE/EC delivery agent replace their incandescent lights with compact fluorescent lights free of charge.
2. Farmers (and other businesses) could receive a free lighting review and apply for up to 80% funding for efficient lighting upgrades installed through an EE/EC delivery agent (for example, high performance T8s, light emitting diodes).
3. Farmers (and businesses) could receive partial funding for specific EE/EC measures (e.g. specific lighting types) through an EE/EC delivery agent.
4. Farmers could apply for up to 50% funding for EE/EC measures such as lighting through the NS Department of Agriculture (NSDA).

In 2005, 58% of NS farmers used efficient lighting, so some of those farmers must have made additional lighting upgrades by 2012. However, these survey results do not explain to what extent the lighting had been replaced on the farm. A farmer could have one LED light or a full lighting upgrade could have been implemented on the entire operation.

Therefore, it is likely that there are still many farms with additional opportunities for efficient lighting.

In 2005, 75% of NS farmers used insulation in their farm buildings and it was the second most prevalent EE/EC upgrade choice between 2007 and 2012 with 41.4% of farms making an insulation upgrade (Bailey *et al.,* 2008). Efficient windows were the third most utilized EE/EC upgrade with 25.6% of farms selecting this upgrade between 2007 and 2012 (46% of NS farms used efficient windows in 2005). Although these responses indicate a positive change, they do not reflect the extent of the implementation and there may still be additional opportunities. While there was funding and support programming was available for NS farmers for these types of upgrades, it was not specific to the technology, typically covered less of the upgrade cost, and the application process required planning ahead; for example (Bailey, 2010; Nova Scotia Federation of Agriculture, 2012b):

1. Larger farms (and businesses) could receive up to 50% funding through an EE/EC delivery agent for measures that reduced electricity but the process required an energy audit and feasibility study and the costs for these assessments were deductible from the overall incentive.
2. Farmers could receive partial funding for specific EE measures through an EE/EC delivery agent.
3. Farmers could apply for up to 50% funding for energy efficient measures such as insulation and windows through the NS Department of Agriculture. This is the same NSDA program that is listed above that was applicable to lighting. This program opened for applications once per year and was open to registered farms with an Environmental Farm Plan and with annual GFR >$10,000 (except for new entrants). Additionally, the program included multiple environmental items that could be funded under a maximum cap. Therefore, farmers applied for a project, such as a manure storage, they likely would not be able to apply for anything else.
4. The Energy Pilot program administered by the NSDA provided up to 75% funding for innovative agricultural energy projects. This program was targeted at projects that were not currently being done on NS farms.

In 2005, less than 10% of farms used RE options (Bailey *et al.,* 2008). Between 2007 and 2012, 28.2% ± 5.0% of NS farmers had made a RE upgrade (including wood). This shows a major shift towards RE with almost three times as many farmers making RE upgrades than using RE in 2005. The most popular upgrades between 2007 and 2012 included wood, photovoltaics, passive solar, ground-source heat pumps, air-source heat pumps and solar water (Table 3.1). Noteworthy improvements from 2005 include:

- no farms used ground-source heat pumps in 2005 and 5.1% implemented this upgrade between 2007 and 2012;
- 4% of farms used photovoltaics in 2005 and 8.5% implemented an upgrade between 2007 and 2012;
- 2% of farms used solar water in 2005 and 4% implemented an upgrade between 2007 and 2012.
- 5% of farms used passive solar in 2005 and 5.5% implemented an upgrade between 2007 and 2012.
- 4% of farms used solar air in 2005 and 2.6% implemented an upgrade between 2007 and 2012; and
- 4% of farms used wind in 2005 and 2.2% implemented an upgrade between 2007 and 2012.

Funding programs were available for NS farmers for RE projects during 2007-2012. For example (Bailey, 2010; Nova Scotia Federation of Agriculture, 2012b; Nova Scotia Department of Energy, 2010; Canadian Solar Industries Association, 2012):

1. The NSDA funding program listed above for EC/EE measures also included RE projects.
2. The Energy Pilot program administered by the NSDA provided up to 75% funding for innovative agricultural energy projects.
3. Available federal programs included ecoEnergy for Renewable Power (1cent/kwh incentive for renewable electricity), ecoEnergy for Renewable Heat (solar air and solar water), ecoEnergy Retrofit Program (energy and pollution-saving upgrades) and the Accelerated Capital Cost Allowance.
4. Solar air and solar hot water rebates were available through a NS EE/EC delivery agent.

5. Nova Scotia Power net-metering program was available for small scale renewable electricity projects. This was followed by the Enhanced Net Metering program in 2010.
6. The Community Feed-In Tariff (COMFIT) was launched in NS in 2010 making it more attractive for large projects such as biogas digesters to move ahead.

In 2012, no farms reported using biogas technologies; however, in 2014, a biogas system on a NS dairy farm began generating electricity (Campbell, 2014). Additionally, a centralized biogas facility that utilizes mink farm waste as a feedstock became operational in 2013; electrical generation began in 2015 (Quest Nova Scotia Caucus, 2015). This is likely associated with the COMFIT program (Nova Scotia Department of Energy, 2010). Prior to the COMFIT program release in 2010, there was little support in NS for RE for electrical generation, leading to little implementation (Mosher and Corscadden, 2012). A feed-in-tariff (FIT) policy encourages RE investment through financial incentive over time (Mosher and Corscadden, 2012). Lack of implementation of RE, especially high capital RE like biogas, may be due to lack of appropriate financing and reluctance to invest in RE (Masini and Menichetti, 2012). Policies can help reduce risk associated with investment decisions by decreasing market uncertainty (Masini and Menichetti, 2012). Investments may be affected by the policy scheme; dedicated policies can stimulate RE investment and feed-in-tariffs may be a very effective policy instrument to attract this investment (Masini and Menichetti, 2012).

Table 3.1 Percentage of NS farms implementing EE/EC and RE upgrades between 2007 and 2012

EE/EC Option used	n	%	RE Option used	n	%
lighting	140	51.3	Wood	27	9.9
insulation	113	41.4	PV	23	8.5
windows	70	25.6	Passive solar	15	5.5
natural ventilation	67	24.5	GSHP	14	5.1
vehicle	45	16.5	ASHP	11	4.0
thermostat	39	14.3	Solar water	11	4.0
furnace	36	13.2	Solar air	7	2.6
heat recovery	33	12.1	Wind	6	2.2
motors	29	10.6	Biofuel	5	1.8
fans	26	9.5	Ag Biomass	4	1.5
heat exchanger	26	9.5	Hydro	1	0.4
zero energy water	20	7.3	Biogas	0	0.0
variable speed drive	13	4.8	Tidal	0	0.0

A number of farms have implemented both EE/EC and RE upgrades (23.4% ± 4.7%). There is a significant relationship between implementing both EE/EC and RE on the farm ($p=0.001$). NS farmers who have implemented a RE upgrade have also likely implemented an EE/EC upgrade. Therefore, there is an opportunity to encourage RE implementation through EE/EC programs.

3.5.3 Decision-making

There are many reasons for choosing to implement EE/EC and RE upgrades. Additionally, a range of factors can influence someone's choice of one technology over another. A comprehensive list of reasons was generated through interviews (see Section 3.4) and used in the survey. The following sections describe the reasons commonly used by NS farmers and which ones are relevant to EE/EC versus RE implementation.

3.5.3.1 Reasons for implementing

67.8% of those who implemented an EE/EC upgrade indicated that their main reason for doing so was monetary (Table 3.2). Over half (53.8%) of all of the reasons for making an EE/EC upgrade were monetary (Figure 3.1). 52.2% of those who use RE indicated that their main reason for doing so was monetary (Table 3.2); 48.7% of all of the reasons for making a RE upgrade were monetary (Figure 3.1). While monetary reasons were important for both EE/EC and RE, it was less so for RE. Social reasons were more prevalent for RE. Environmental reasons were the least important for EE/EC and RE. Three main reasons for implementing an EE/EC upgrade, in order of importance were: to save money, to save energy, and necessity (Table 3.2). Three main reasons for implementing a RE upgrade in order of importance were: to save money, self-sufficiency, and necessity. Saving money and necessity were the main common reasons for implementing both EE/EC and RE. Improving animal welfare is also a noteworthy main reason among EE/EC and RE upgrades.

Table 3.2 Main reasons for implementing EE/EC and RE (sorted by theme and listed from highest to lowest for combined percentages for EE/EC and RE)

Main reason category	Main reason	EE/EC	RE
Monetary	save money	34.2	31.9
	save energy	24.3	8.7
	operating cost stability	2.0	5.8
	improve production	3.3	4.3
	operating cost predictability	1.3	1.4
	grants/rebates	2.6	0.0
	total	**67.8**	**52.2**
Environmental	decrease air emissions	0.7	0.0
	improve water quality	0.7	0.0
	reduce waste	0.7	0.0
	total	**2.0**	**0.0**
Social	to be self-sufficient	1.3	13.0
	improve animal welfare	5.9	5.8
	save time	2.0	2.9
	improve work environment	2.0	1.4
	improve safety	0.0	2.9
	to be innovative	0.7	1.4
	reduce noise	0.0	1.4
	regulatory	1.3	0.0
	improve reputation	0.0	0.0
	what others are doing	0.0	0.0
	total	**13.2**	**29.0**
Other	necessity	7.9	11.6
	renovating	4.6	1.4
	other	1.3	2.9
	building new	2.0	1.4
	recommended	1.3	1.4
	total	**17.1**	**18.8**

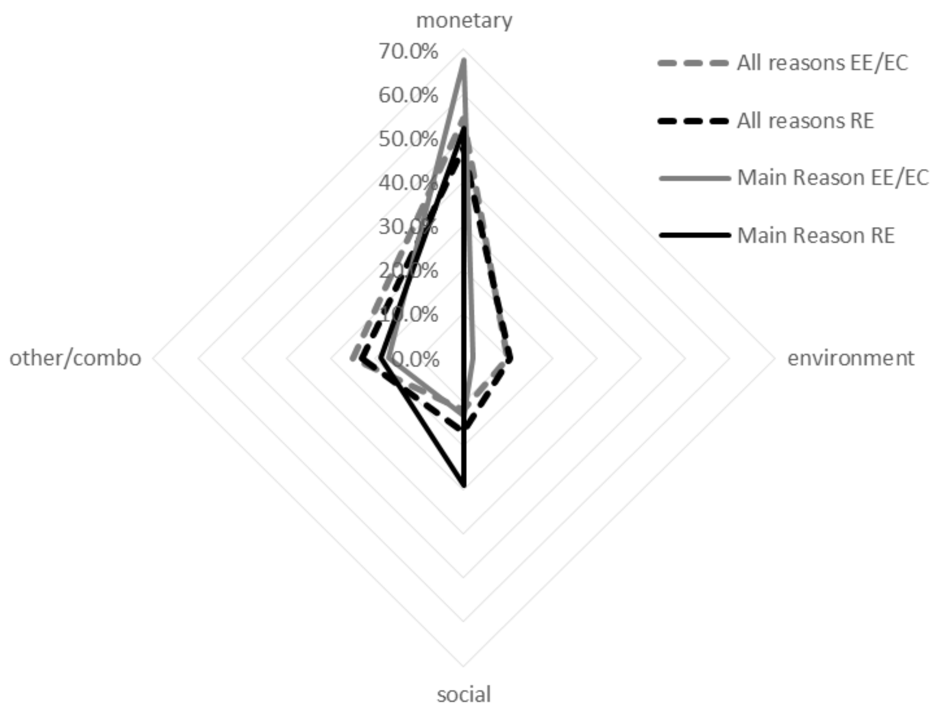

Figure 3.1 Percentage of all reasons and main reasons for implementing an EE/EC or RE upgrade sorted by category

In contrast to the main reasons (Table 3.2), there are many other reasons for NS farmers to implement an EE/EC or RE upgrade (Figure 3.2). When looking at all the reasons individually, there are some notable similarities and differences between reasons for implementing EE/EC and reasons for implementing RE. For both EE/EC and RE, prevalent reasons to implement included: to save money and to save energy (>35% of those who did an upgrade indicated this as a reason for implementing). Operating cost stability was also fairly important to farmers for both EE/EC and RE when considering whether to make an upgrade (>25% of those made an upgrade listed this as a reason). Operating cost predictability and renovating were fairly important for EE/EC. For RE, being self-sufficient was very important and being innovative was fairly important. Significantly more NS farmers listed saving energy and renovating as reasons to make an EE/EC upgrade compared to the reasons for making a RE upgrade (p=0.001, p=0.048 respectively). Significantly more NS farmers listed self-sufficiency and to be innovative as reasons to make a RE upgrade compared to the reasons for making an EE/EC upgrade (p=0, p=0.001 respectively).

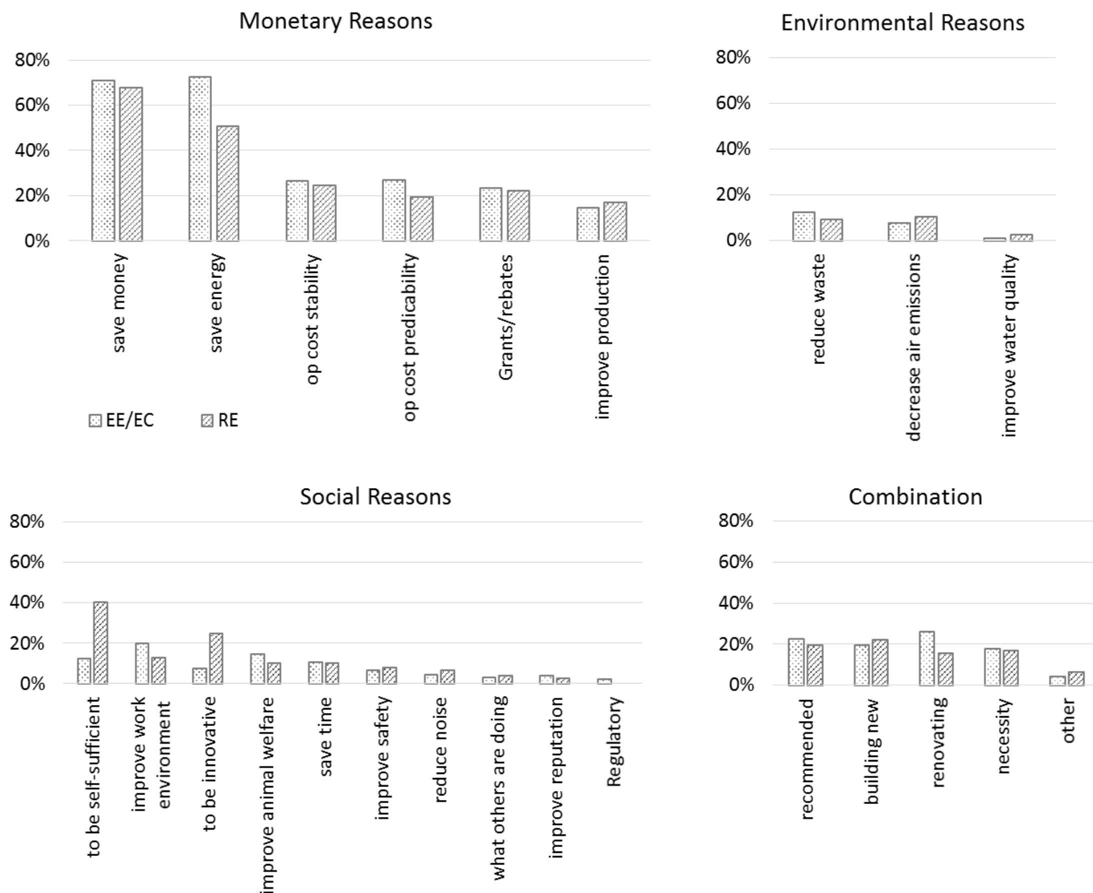

Figure 3.2 Reasons for implementing EE/EC and RE upgrades (percentage of farmers indicating a reason, sorted by theme and listed from highest to lowest for combined percentages for EE/EC and RE)

Self-sufficiency has been linked to farming throughout history (Loehr, 1952). It is not surprising that self-sufficiency is relevant for decision-making on the farm. It is noteworthy that, for NS farmers, self-sufficiency seems to be relevant for RE decisions and less so for EE/EC. EE/EC options can reduce energy use and are a fundamental precursor to RE implementation. Reducing energy use is a prevalent reason for implementing EE/EC options and those who have implemented a RE upgrade have also likely implemented an EE/EC upgrade. Therefore, there is likely some awareness amongst NS farmers that EE/EC upgrades should be considered before RE upgrades.

Although renovating and building something new did not show up as main reasons for farmers to implement EE/EC or RE upgrades, there are relationships worth mentioning.

63.4% of NS farmers had done some kind of renovation on the farm in the past five years. Fewer farmers did new construction, with 41.4% of respondents building something new in the past five years. There is a significant relationship (p=0) between renovating and EE/EC implementation. There is a marginally significant relationship for RE implementation and renovating (p=0.055). Those who are renovating are significantly more likely to implement EE/EC options (80%) and marginally more likely to implement RE (32.4%). 73.1% of those who use EE/EC have renovated. There is no significant relationship (p=.181) between new construction and EE/EC implementation. There is a significant relationship for RE implementation and new construction (p=0.005). Those who have done new construction are significantly more likely to implement RE (38% of those who have done new construction have implemented RE). 54% of those who use RE have done some sort of new construction.

There is an opportunity to incorporate EC/EE and RE options during a renovation or new construction. Buildings age and become less energy-efficient through their lifetime (Jensen and Maslesa, 2015). Higher energy prices and an increased focus on sustainability are reasons to renovate (Jensen and Maslesa, 2015). There are also several energy-related programs in NS targeted at renovating and new construction (Efficiency Nova Scotia Corporation, 2013b).

3.5.3.2 Consideration of alternatives

38.0% of those who implemented an EE/EC upgrade considered more than one alternative during selection of their technology. 45.5% of those who implemented a RE upgrade considered more than one alternative during selection of their technology. These percentages are not significantly different (p=0.269).

For EE/EC upgrades, 44.8% of the main reasons for selecting one technology over another were monetary (Table 3.4). 33.3% of all of the reasons for making an EE/EC upgrade were monetary (Figure 3.3). For RE upgrades, 39.3% of the main reasons for selecting one technology or another were monetary (Table 3.4). 33.5% of all of the reasons for selecting one RE technology or another were monetary (Figure 3.3).

Environmental considerations were not a main reason for selecting one technology over another for EE/EC and RE; however, they are an important consideration overall.

Table 3.3 Main reasons for considering alternatives when selecting EE/EC and RE upgrades (sorted by theme and listed from highest to lowest for combined percentages for EE/EC and RE)

Main reason category	Main reason	EE/EC	RE
Monetary	lower capital cost	20.7	17.9
	payback	15.5	17.9
	grants/rebates	5.2	3.6
	lower maintenance	3.4	0.0
	total	**44.8**	**39.3**
Environmental	environment	3.4	0.0
	less waste	0.0	0.0
	total	**3.4**	**0.0**
Social	preference	1.7	10.7
	availability	3.4	3.6
	lower risk	1.7	3.6
	buy local	0.0	3.6
	what others are doing	0.0	3.6
	practical	3.4	0.0
	animal welfare	1.7	0.0
	convenience	1.7	0.0
	less noise	1.7	0.0
	familiarity	0.0	0.0
	innovative	0.0	0.0
	avoid regulation	0.0	0.0
	safer	0.0	0.0
	simplicity	0.0	0.0
	total	**15.5**	**25.0**
Technical	more efficient	10.3	14.3
	proven	1.7	3.6
	compatibility	0.0	3.6
	functionality	3.4	0.0
	durability	0.0	0.0
	longevity	0.0	0.0
	tech appearance	0.0	0.0
	tech reputation	0.0	0.0
	warranty	0.0	0.0
	total	**15.5**	**21.4**
Other/combination	best in long term	12.1	7.1
	other	5.2	3.6
	recommended	0.0	3.6
	best in short term	3.4	0.0
	total	**20.7**	**14.3**

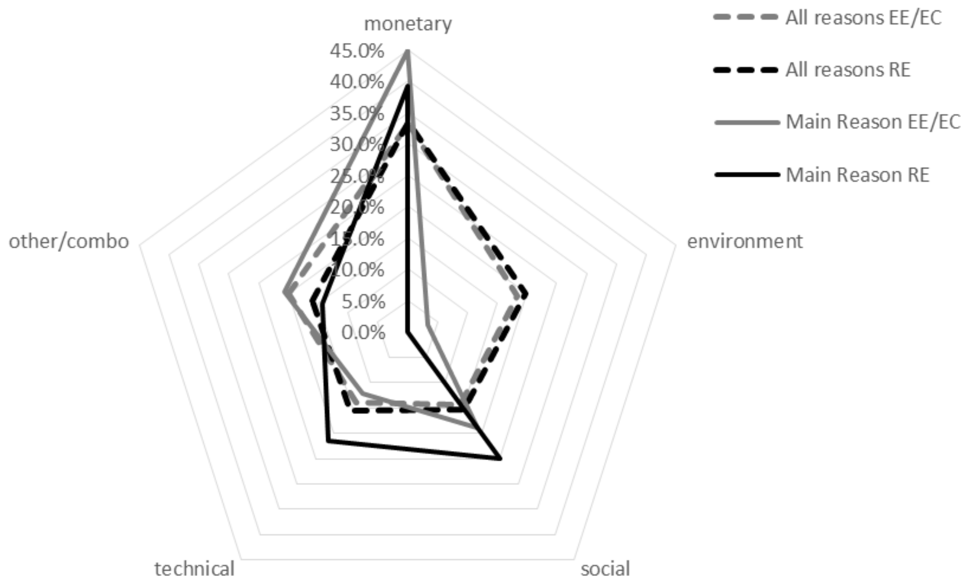

Figure 3.3 Percentage of all reasons and main reasons for selecting one technology over another sorted by category

There are many other reasons for NS farmers to select one EE/EC or RE technology over another. When looking at all the reasons individually, there are some notable similarities and differences (Figure 3.4). For both EE/EC and RE, selecting a technology that was best in the long term, more efficient, and had a good payback and low capital costs were all important (>35% of those who considered alternatives listed it as a reason). Lower maintenance, environment and functionality were also fairly important for both EE/EC and RE when selecting among technologies (>25% of those who considered alternatives listed it as a reason). Practicality was fairly important for EE/EC. Availability, simplicity, grants/rebates, innovation, and preference were fairly important for RE.

More NS farmers listed simplicity as a reason when deciding among RE options compared to selecting between EE/EC options (this is marginally significant, $p=0.086$). While not significantly different, more NS farmers considered availability and preference when selecting RE alternatives compared to selecting EE/EC alternatives ($p=0.182$ and $p=0.215$ respectively). Also, while not significantly different, more NS farmers considered compatibility, best in the short term, and recommended when selecting EE/EC alternatives vs RE alternatives ($p=0.11$, $p=0.148$ and $p=0.148$ respectively).

It was surprising to see that warranty was not an important consideration when deciding between EE/EC or RE options.

Overall, the decision process that NS farmers go through when considering energy alternatives seems to be more balanced among the pillars of sustainability compared to the decision process on whether to implement and energy upgrade. This means that in order to implement an EE/EC upgrade a farmer mostly considers monetary aspects, but will consider social, environmental and technical aspects when comparing alternatives. This is true for RE upgrades as well, but social aspects are a secondary factor (second to monetary) in implementing a RE upgrade.

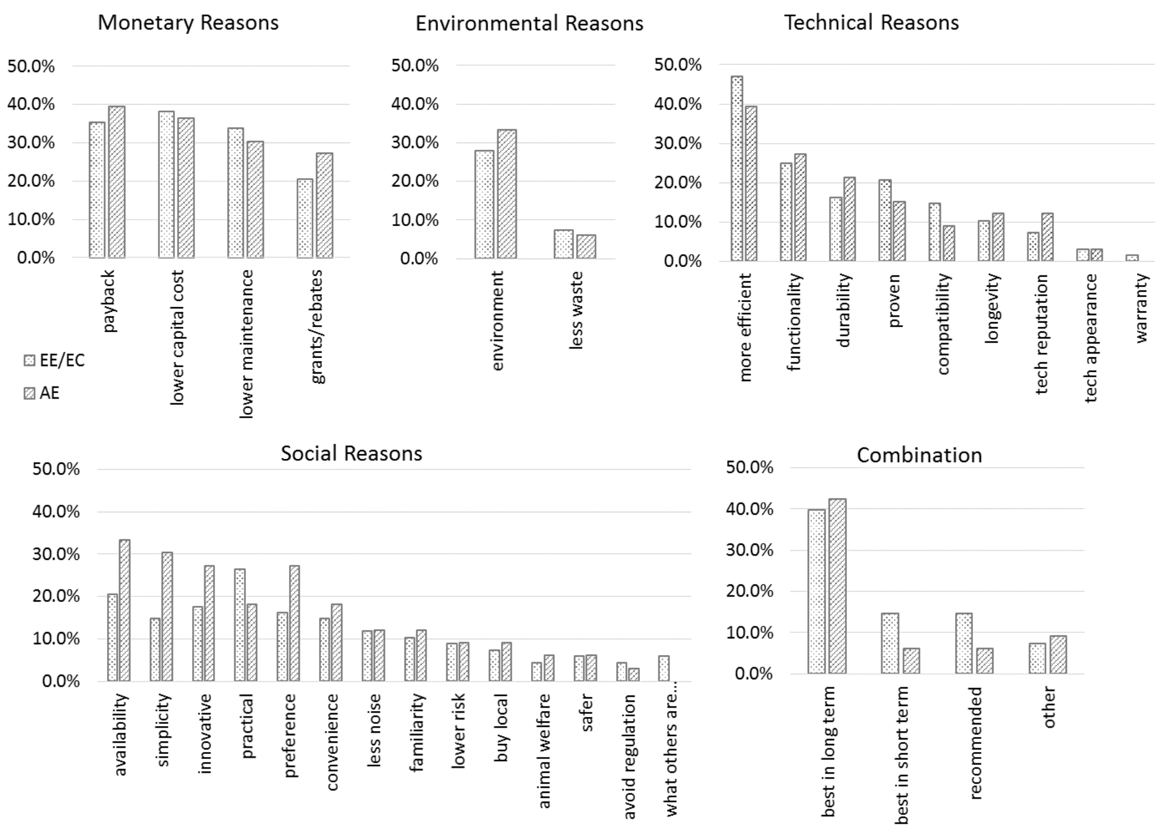

Figure 3.4 Reasons for considering alternatives when selecting EE/EC and RE upgrades (percentage of farmers indicating a reason, sorted by theme and listed from highest to lowest for combined percentages for EE/EC and RE).

3.5.4 Support

In additional to funding programs, other types of support can be provided to assist with energy decision-making. Services are an alternative to direct funding. A Farm Energy Specialist position existed with the NS Department of Agriculture from 2007 to 2012. An Industry Research Chair position in Farm Energy Conservation and Farm Energy Nova Scotia (FENS), a group of researchers and industry representatives, existed through the Dalhousie University Agricultural Campus from 2009 to 2014 (Dalhousie University Faculty of Agriculture, 2014; Farm Focus, 2009). An energy efficiency agency was created to serve NS in 2006 (Muir, 2006). It was originally Conserve NS, a crown corporation, and was changed to Efficiency NS, an independent administrator, in 2010 (White, 2009).

NS farmers received various types of support services to help guide their energy decisions, including: energy audits, equipment reviews, farm visits by a professional and/or information provided by a professional. Some NS farmers received support from multiple sources. Overall, 36.0% of NS farmers received some support to help guide their energy decisions (Bailey *et al.,* 2016).

There is a significant relationship between NS farmers who received support and those who implemented EE/EC or RE (p=0 and p=0.003 respectively). Those who received support were more likely to implement EE/EC and/or RE. 87.8% of those who received support implemented EE/EC (58.6% of those who had no support implemented EE/EC); 47.5% of those who implemented EE/EC had some support (14.3% of those who did not implement received support). All types of support were significantly related to implementing EE/EC, including: energy audits, equipment reviews, farm visits by a professional and information provided by a professional (p=0.003, p=0.002, p=0.001 and p=0.007 respectively). 38.8% of those who received support implemented RE (22.4% of those who had no support implemented RE); 49.4% of those who implemented RE had some support (30.8% of those who did not implement received support). When looking at the types of support, an energy audit was the only type that was significantly related to implementing RE (p=0.006).

In addition to participating in energy-related support programming, NS farmers' decisions were influenced by service providers and peers (including family, friends and other farmers). 42.7% of those who implemented an EE/EC upgrade had someone influence their decision. 41.3% of the time, the main influencer in making an EE/EC upgrade decision was family, friends, peers and other farmers (Figure 3.5).

44.6% of those who implemented a RE upgrade had someone influence their decision. 53.6% of the time, the main influencer in making a RE upgrade decision was a peer (including family, friends and other farmers). Family, friends, peers and other farmers are the main influencers for both EE/EC and RE. Their influence is higher for RE than EE/EC. Unpaid service providers have less influence for RE than EE/EC.

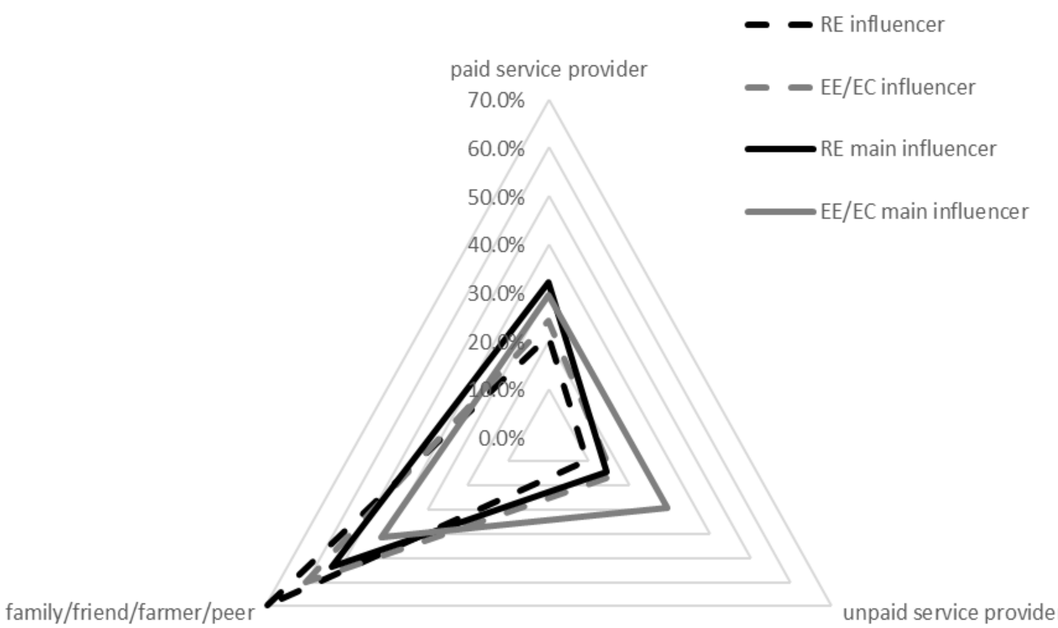

Figure 3.5 Percentage of all influencers and main influencers for selecting implementing EE/EC or RE by category

Conserve NS/Efficiency NS, the Farm Energy Specialist, FENS and the Industry Research Chair all provided unpaid services. Unpaid service providers played a larger role (with respect to influencing decisions) for EE/EC decision-making compared to RE decision-making. This may be related to the focus of the services provided at the time. Although the services provided from these organizations included some RE support, the names of the unpaid service providers - "efficiency", "conserve", "energy conservation" shed some light on the main focus of these organizations.

3.5.5 Information delivery

The Internet was used more for RE information delivery than EE/EC (Table 3.4). Energy audits were used more for EE/EC information delivery than RE information delivery. Visiting other farms, the Internet and factsheets are still the top three individual methods of information delivery for both EE/EC and RE. Having someone visit the farm is a notable information delivery method for both EE/EC and RE.

Table 3.4 Preferred information delivery mechanisms (percentage of respondents using mechanism, listed from highest to lowest for combined percentages for EE/EC and RE)

Information Delivery Mechanism	EE/EC [%] (n=177)	RE [%] (n=73)
internet	23.0	37.0
I visited other farms	24.2	23.3
other*	20.8	21.9
factsheets	18	23.3
someone visited my farm	16.3	15.1
tradeshow	9.6	11.0
energy audit	14.6	5.5
telephone	5.1	8.2
email	4.5	8.2
conference	5.6	5.5
meeting	5.6	4.1
workshop	0.6	1.4

*respondents listed peers, family, self, service providers, media (printed and electronic), and an exhibition under "other"

The information delivery mechanisms can be sorted into four broad themes: receiving information from other people, media, self (i.e. knowledge) and events.

For EE/EC:

- 49.8% of the information delivery mechanisms used were via other people (energy audits, service providers, peers, visiting other farms, someone visiting, telephone, email).

- 31.2% of the information delivery mechanisms used were via media (the Internet, printed and electronic media).
- 14.4% of the information delivery mechanisms used were via an event (tradeshow, workshop, meeting, conference).
- 4.6% of the information delivery mechanisms used were via personal knowledge (6.7% of respondents claimed to know already what they needed).

For RE:

- 42.0% of the information delivery mechanisms used were via other people.
- 40.3% of the information delivery mechanisms used were via media.
- 13.4% of the information delivery mechanisms used were via events.
- 4.2% of the information delivery mechanisms used were via personal knowledge (6.8% of respondents claimed to know already what they needed).

Receiving information via other people is most often used, and as previously mentioned, those who were influenced in their EE/EC and RE decision-making were influenced mostly by family, friends, peers and other farmers. Additionally, receiving information via media (especially the internet) is often used (more so for RE). Therefore, utilizing case studies, available online, featuring other farms may be a strategy to consider for effective information delivery. Farm tours may also be effective. Although energy audits were utilized more for EE/EC, farmers who had an energy audit were more likely to implement RE, so energy audits should be considered as a tool for RE-related programming.

3.5.6 Obstacles

There are many potential barriers or obstacles to EE/EC and RE implementation. These can include cost-effectiveness, technical barriers, market barriers, political/regulatory barriers and social and environmental barriers (Painuly, 2001). NS farmers who implemented EE/EC and RE were asked to identify specific obstacles to implementation (Table 3.5). Only 18.6% of those who implemented EE/EC options ran into obstacles and this was not significantly different for RE implementation (14.1% of those who implemented RE options ran into obstacles). Monetary obstacles seem to be more prevalent for EE/EC than RE; they represent 37.7% of EE/EC obstacles and 13.6% of RE obstacles. Non-monetary obstacles (e.g. lack of information, lack of time, material availability) made up most of the obstacles for EE/EC and RE implementation. Lack of time was more of an obstacle for EE/EC than RE. Availability of materials and labour (lack of labour and contractor availability) as well as messaging and red tape seem to be larger obstacles for RE than EE/EC.

Table 3.5 Obstacles to Implementation (listed from highest to lowest for combined percentages for EE/EC and RE)

Obstacle	EE/EC [%] (n=177)	RE [%] (n=71)
material availability	18.2	40.0
other*	24.2	30.0
contractor availability	18.2	30.0
lack of information	21.2	20.0
lack of funding	27.3	10.0
lack of time	21.2	10.0
lack of capital	30.3	0
lack of labour	6.1	20.0
mixed messages	6.1	20.0
red tape	3.0	20.0
scheduling conflict	6.1	10.0
lack of financing	3.0	10.0

* Respondents listed insurance, lack of space, unexpected costs, waste management, misinformation, funding timeframes, and lack of assistance for invention under "other".

Lack of funding and lack of capital are listed as obstacles for EE/EC. At the time of the survey, funding did exist for various EE/EC technologies specific to agriculture through the NSDA (Nova Scotia Federation of Agriculture, 2012b). However, the NSDA funding programming is typically only available for application once per year for a limited time (Nova Scotia Department of Agriculture, 2015b). Shortly after this survey, Efficiency NS created a funding program for efficient agricultural technologies (Efficiency Nova Scotia Corporation, 2015). Also, contractor and material availability are listed as obstacles for RE implementation. This is not unexpected as the RE sector in NS saw a large percentage increase in the number of farmers implementing RE. In some cases, the implementation of specific technologies tripled (e.g. photovoltaics). This puts demand on contractors and materials. NS farmers did indicate that availability was a fairly important consideration when deciding between technologies. When designing programs and policies to promote

EE/EC and RE implementation, a strategy around contractor and material availability should be developed in order to mitigate obstacles. Even an easily accessible list of contractors/vendors may help alleviate this barrier.

For this analysis, the barriers/obstacles provided by respondents are only for those who implemented an energy upgrade and therefore these obstacles are not insurmountable. Those who did not implement were not asked a similar question but the results of a similar question would help identify specific impediments to implementation.

3.5.7 Energy sources replaced/offset/ supplemented

The agriculture sector is heavily dependent on fossil fuels (Bardi, El Asmar and Lavacchi, 2013). Reductions in fossil fuel availability and increasing costs will create large problems for the agricultural sector (Bardi, El Asmar and Lavacchi, 2013). RE and EE/EC can help mitigate these problems and help agriculture adapt to reduce dependency on fossil fuels, a trend that is already underway (Bardi, El Asmar and Lavacchi, 2013).

Historically, electricity generation in NS relied heavily on fossil fuels (Nova Scotia Power Inc., 2015). Dependence on fossil fuels, and electricity generated mainly from fossil fuels, makes NS farmers vulnerable to fluctuating energy prices and potentially insecure imported energy supplies. There have been recent changes to the make up of NS electricity with an increase in renewable-energy-based generation. The 2009 Nova Scotia Energy Strategy vision is a sustainable energy future (Nova Scotia Department of Energy, 2009). The strategy lists increased RE as a main policy for NS (Nova Scotia Department of Energy, 2009). NS has a target of 25% renewable electricity by 2015 and 40% by 2020 (Nova Scotia Department of Energy, 2010). Electricity in NS is becoming a more sustainable energy choice than it has been in the past. Renewable electric power on the farm, whether from the grid or generated on-farm, may play a part in the transition to move agriculture towards sustainability (Bardi, El Asmar and Lavacchi, 2013).
Between 2007 and 2012, 64.9% of those who implemented RE upgrades replaced existing equipment. These farmers were asked about the energy source they replaced/offset or supplemented when they replaced existing equipment. Electricity was

replaced/offset/supplemented 50% of the time, followed by oil (36%), wood (22%), propane (6%) diesel (4%), gasoline (2%) and other (2%). Replacing, offsetting and supplementing electricity and oil between 2007 and 2012 demonstrates a positive move towards sustainability.

3.6 Conclusion

A large majority of registered NS farmers implemented an EE/EC or RE upgrade on the farm between 2007 and 2012 (72.9%). These upgrades have resulted in large energy reductions and savings on energy expenses on NS farms. Few farmers who implemented EE/EC or RE indicated obstacles to implementation (18.6% and 14.1% respectively). Non-monetary obstacles (e.g. lack of information, lack of time, material and contractor availability) make up most of the obstacles for EE/EC and RE implementation. Monetary obstacles were more prevalent for EE/EC than RE implementation. This points to opportunities for encouraging implementation. Focusing programming on monetary measures alone may not address the true barriers to implementation. This concept is demonstrated when looking at the most-implemented upgrade on NS farms at the time: efficient lighting (51.2% of NS farmers completing an upgrade between 2007 and 2012). A suite of lighting programs removed monetary barriers (efficient lighting was either heavily funded or free). Non-monetary barriers, such as lack of time and materials, were addressed by having a delivery agent assess and install lighting options. When promoting energy technologies, it is necessary to consider the resources that may, or may not, be available for implementation, such as contractors, materials, time and information.

More farmers implemented EE/EC upgrades than RE upgrades (68.9% versus 28.2%). Implementing an EE/EC upgrade increased the likelihood of implementing a RE upgrade. Also, those who were doing new construction were significantly more likely to implement a RE upgrade and those who are renovating are significantly more likely to implement EE/EC upgrades. While some EE/EC and RE programming in NS may target those who want to renovate or build new, augmenting this strategy should be considered. Linking RE implementation to new construction programs and EE/EC implementation to renovation programs seem to be effective program strategies. However, there seems to be a broken link between RE decision-making and renovation programs and EE/EC decision-making and new construction programs. New construction codes/guides already include some EE/EC requirements so perhaps NS farmers do not consider EE/EC implementation a decision that they can make (National Research Council of Canada, 2011). The reality is that there are many EE/EC decisions that can be made during new construction. Additional RE education through EE/EC programming and renovation targeted programming may be effective. Additional EE/EC education through new construction targeted programming should be considered.

There has been a large increase in the implementation of RE since 2005. The most popular RE upgrades between 2007 and 2012 included wood, photovoltaics, passive solar, ground source heat pumps, air source heat pumps and solar water. 64.9% of those who implemented a RE upgrade replaced existing equipment. Electricity and oil were replaced, offset or supplemented most of the time (50% and 36% respectively). There is a positive move towards sustainability in NS where fossil fuels have been primary energy sources. RE can reduce carbon emissions and fossil fuel consumption but require large capital investment (Masini and Menichetti, 2012). Prior to 2012, little had been done on NS farms around large scale renewable electricity. The COMFIT program that existed from 2010 to 2015 resulted in growth in an area on NS farms that had previously been ignored. There is an opportunity for future growth in this area following the heels of successful projects. These successes not only improve awareness but may make it easier to get financing to move forward. Proven reliability of a technology helps gain investor confidence (Masini and Menichetti, 2012).

Half of the NS farmers who implemented EE/EC and/or RE received information via other people. Almost half of registered NS farmers who implemented an EE/EC or RE upgrade indicated they were influenced by someone in their decision making. Also, family, friends and peers are the main influencers for both EE/EC and RE. Unpaid service providers had less influence for RE than EE/EC. This may have been due to the focused programming on EE/EC at the time. Service providers already have some demonstrated influence on EE/EC decision-making and implementing an EE/EC upgrade on NS farms increases the likelihood of implementing a RE upgrade. Those who had an energy audit were also more likely to implement RE. Therefore, there is an opportunity for service providers (paid and unpaid) to be effective in providing more support (e.g. increased RE support via energy audits). EE/EC and RE information delivery via other people (i.e. energy audits, site visits) is effective but alternative methods, such as utilizing case studies available online featuring other farms, may also be effective support programming.

Overall, the decision process that NS farmers go through when considering energy alternatives seems to be more balanced among the pillars of sustainability compared to the decision process to implement an energy upgrade. This means that in order to implement an EE/EC upgrade, a farmer mostly considers monetary aspects, but will consider social, environmental, and technical aspects when comparing alternatives. This is true for RE upgrades as well but social aspects are a secondary factor (second to monetary) in implementing a RE upgrade. The focus on monetary drivers may be linked to the type of support offered. NS farmers who received support were more likely to implement EE/EC and RE. All types of support were significantly related to implementing EE/EC (energy audits, equipment reviews, farm visits by a professional and/or information provided by a professional). However, an energy audit was the only type of support that was significantly related to implementing RE and RE decision-making included monetary and social considerations. Perhaps energy audits provide a level of support that promotes sustainability that other types of support do not. Energy audits tend to provide a comprehensive review of current energy usage and best options for improvements based on cost-benefit analysis. Perhaps this foundation, that removes some of the uncertainty around monetary factors, allows for deliberation on non-monetary factors. Regardless, an energy audit is an effective tool in promoting EE/EC and RE implementation. In order to encourage sustainability as a motivator to implement an energy upgrade, an additional tool (e.g. framework) to incorporate sustainability considerations in the decision-making process would be a valuable resource. Further research could include consideration of interdependencies (Gottschamer and Zhang,

2016) amongst factors (e.g. social, monetary, environmental, and technical) to provide novel insights.

The energy reductions on NS farms through EE/EC and RE implementation is a tremendous accomplishment. This is a success story that should be celebrated. However, there are still opportunities for further reductions. Further research is needed to identify those opportunities and identify effective policies and tools to ensure continued success.

3.7 ACKNOWLEDGEMENTS

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CHAPTER 4 AGRICULTURAL ENERGY OPPORTUNTIES IN NOVA SCOTIA

4.1 INTRODUCTION

Over the past several years there has been an increased focus on the implementation of energy conservation (EC), energy efficiency (EE), and renewable energy (RE) technologies in Canada and in many other countries around the world (International Renewable Energy Agency, Renewable Energy Policy Network for the 21st Century and International Energy Agency, 2018; Natural Resources Canada's Office of Energy Efficiency, 2014; International Energy Agency, 2016; Environment Canada, 2013). Provincially, in NS, with the Environmental Goals and Sustainable Prosperity Act (EGSPA) coming into law in 2007, many policies and programs were designed to encourage EC, EE, and RE, resulting in implementation (Province of Nova Scotia, 2017). In NS, many energy related programs and policies have run their course, for example:

- The Community Feed-in Tariff (COMFIT) program began in 2010 and provides incentives to renewable electricity projects; it stopped accepting applications in 2015 (Nova Scotia Department of Energy, 2018; Nova Scotia Department of Energy, 2010).
- The Growing Forward programs administered by the NS Department of Agriculture provided incentives for EC, EE and RE and these programs have concluded in 2018 (Nova Scotia Department of Agriculture, 2015b; Bailey, 2010).
- The enhanced net metering maximum nameplate capacity decreased from 1,000 kW to 100 kW in 2015 (Nova Scotia Power Inc., 2017).

These programs and policies have resulted in energy savings and implementation. For example in 2015, more than 26% of total electricity produced in NS was from renewable sources compared to 10% in 2006 (Province of Nova Scotia, 2008; Province of Nova Scotia, 2017). Also, in the agricultural sector, 73% of NS farmers implemented an EC, EE or RE upgrade between 2017 and 2012 (Bailey *et al.,* 2018). This chapter examines the potential energy opportunities for NS farms. It helps transition from energy decisions that have been made (Chapters 2 and 3) to a method for making future decisions (Chapter 5).

4.2 METHOD

A mail survey of 2393 members of the Nova Scotia Federation of Agriculture (NSFA) was conducted in April 2012, and repeated in November 2012. The NSFA mail list was used as the sample frame. This is representative of the entire registered farm population since all registered farms are also NSFA members (Nova Scotia Department of Agriculture, 2015a). Farm registration is voluntary and there is an annual fee. Farms must be registered to access government agricultural programs and additionally, gross farm receipts (GFR) must be >$10,000 (except for new registrants) to access many of these programs (Nova Scotia Department of Agriculture, 2015b). Compared to the census, there are fewer farms in the <$10,000 GFR category that are registered (Statistics Canada, 2012d). Although the sample frame captures all registered farms, it does not capture all farms in NS.

The survey was designed to collect information on criteria used for on-farm energy decision-making and to provide evidence for the validity of the decision-making criteria identified in previous interviews. Interviews were conducted between November 2011 and January 2012. The interviews were designed to collect information on criteria used for on-farm energy decision-making. The interview questions also allowed for the identification of barriers and opportunities to implementing energy sustainability options given existing agriculture/energy policies. There were two populations for the interviews: NS farmers who had implemented an energy improvement in the three years prior to the interview, and North American energy professionals with experience conducting on-farm energy audits. There were ten interviews per population. The sampling was purposive and individuals were identified by me in my capacity as the Farm Energy Specialist (FES) with the NS Department of Agriculture (NSDA) from 2007 to 2012.

The sample population was selected to allow for input from those who inform energy decisions and those who make them. The sample size was determined to ensure the capturing of views associated with a range of business types and sizes. The interviews identified the following information used in the survey design: reasons for implementing EE/EC and RE, reasons for considering alternatives when selecting EE/EC and RE upgrades, types of support used for energy decisions, information delivery mechanisms, and obstacles encountered. Using multiple methods such as surveys and interviews (methodological triangulation) is important to increase the credibility and validity of the results (Turner, Cardinal and Burton, 2017; Heesen, Bright and Zucker, 2016).

The survey was divided into five sections (A to E) each with a unique objective. The first section (A) was designed to gather demographic information such as farm type, farmer age, and farm income as well as basic information on energy use and energy concerns. The second section (B) was designed to gather information on energy conservation and energy efficiency options used on the farm and the decision-making criteria used to choose from among these options. Questions were asked on what energy options were used on the farm, reasons for looking at or implementing alternatives, if anyone influenced the decision, where the respondents went for information, and obstacles they may have encountered. The third section (C) was identical to section B except it was about renewable energy options and farmers were asked what energy source they replaced, offset, or supplemented. The fourth section (D) was about future changes. Questions were asked about the energy conservation/efficiency and renewable energy options farmers were interested in using, what would influence their decision to implement, when they planned on retiring, and their retirement plans for the farm. The fifth and final section (E) was a space for comments and ideas.

This paper presents the results from section D with additional information from sections B and C not previously presented.

Between 2007 and 2012, as FES I completed 162 assessments and 29 energy audits on farms in NS. The assessment was either:

1) A Level 1 audit: a walk-through of the farm with an indication of what energy options were suited to the operation with a qualitative indication of potential savings (no formal report) (Thumann and Younger, 2003); or
2) Energy-related work for the farmer that involved a site visit or engineering calculations.

The audit was either:

1) A Level 2 audit: A written report including a detailed inventory of equipment, estimated energy usage, comparison of audit data to energy billing and quantitative measure of potential savings (Thumann and Younger, 2003).
2) A Level 3: Work that went beyond a level 2 audit and included an estimate of energy use based on measurement rather than inventory (actual energy use was measured with equipment) (Thumann and Younger, 2003).

This paper presents data and observations from the audits and assessments completed by me between 2007 and 2012. These results are specifically indicated as from my work as the FES rather than the survey.

4.2.1 Survey design

There were three demographic variables: farm type, farmer age, and farm size. Farmers were asked to indicate the EC, EE, and RE options they were interested in using on their farm in the next five years and were given a list of 30 choices (15 for EE and EC, and 15 for RE). They were also asked to indicate the energy option of most interest to them.

The survey was pre-tested by six volunteers, all with some agricultural experience, to make sure it was clear and unambiguous, and could be completed in a relatively short period of time (30 min).

4.2.2 Survey sampling, administration and response

All surveys included a cover letter and a stamped self-addressed envelope. The cover letter explained the purpose of the survey and the risks and benefits of participation. It also included contact information and a submission deadline. All surveys were anonymous, since the names and addresses were not included in the survey questions. Surveys were mailed in April 2012 to all NSFA members. This was repeated in November 2012 due to a low return rate from the initial mailing. The initial survey was included in the mailing of the April 2012 NSFA Newsletter; the second survey was a stand-alone mail-out sent in November 2012. A reminder notice was sent via mail in the NSFA newsletter and via email in the NSFA e-news within three weeks of the initial mailing.

For the initial mailing, a total of 118 surveys were returned during a 62-day time frame (4.9% return rate). The total number of usable surveys was 102. From the second mailing, a total of 250 surveys were returned during a 42-day time frame (10.5% return rate). The total number of usable surveys was 171. Therefore, when combined, there were a total of 273 usable surveys. If the farmer had previously completed the survey in the first mail out, or was no longer farming, s/he was asked to indicate this and return the survey blank.

Response rate varied among farm types, with an overall response rate of 11.4%. This was lower than expected based on a previous survey in 2005 with a 32% response rate (Bailey, Gordon *et al.,* 2008). Typical mail questionnaires receive anywhere from 10% to 50% response rates (Weisberg, Krosnick and Bowen, 1996).

4.2.3 Data analysis

Predictive Analytics Software (PASW V.17) and Minitab (V.17) were used to analyze the collected data (IBM Corp, 2013; Minitab Inc., 2013). The age distribution from the 2011 Census of Agriculture was compared to survey results on an overall basis to look for significant differences at a 0.05 significance level. To test this null hypothesis, the Chi-square Goodness-of-Fit test was used. The gross farm receipt distribution from the 2011 Census of Agriculture was also compared to survey results on an overall basis to look for significant differences at a 0.05 significance level. To test this null hypothesis, the Chi-square Goodness-of-Fit test was used. Confidence intervals (CI) were calculated at the

95% confidence level. The two-proportion test was used to compare interest levels between 2005 and 2012 at the 0.05 significance level (Moore and McCabe, 2006).

4.3 Results and Discussion

This section presents results and discussion on survey validation, interest in implementing energy opportunities, and opportunity areas by farm type (dairy, beef, and poultry).

4.3.1 Validation

To verify that the results were representative of NS farms, the surveyed distribution of age ranges was compared to the 2011 Agricultural Census (Statistics Canada, 2012d). There were no significant differences using the Chi-Square Goodness-of-Fit test ($p = 0.745$). There were significant differences when comparing the Gross Farm Receipt (GFR) distribution to the 2011 Agricultural Census ($p=0$). The survey had fewer farmers with GFRs <$10,000 than expected. The differences in GFR distribution may be associated with the use of NS Farm Registration for the sample frame. There were 1603 more farmers listed in the census than those registered. Therefore, small farms may be underrepresented in the survey results. However, given that age distribution is representative, it is likely that the survey responses are representative of registered NS farmers, rather than all NS farmers.

4.3.2 Interest in implementing energy opportunities

Survey results indicated that most NS registered farmers were interested in using EE/EC or RE options on the farm (83.0% ± 4.2%) (Figure 4.1). Although slightly higher than interest levels in 2005 (78.0% ± 5.3%), it was not significantly different. It was also noted that 71.1% ± 5.1% of registered farmers were interested in using EE/EC and the same was true for RE. More than half (59.3% ± 5.5%) of NS registered farmers were interested in using both EE/EC and RE options. A minority of NS farmers did not use EE/EC or RE options on the farm (27.1%). Of these, just over half (51.4%) were interested in future implementation. Most of those interested in future implementation were those who already used EE/EC or RE to some extent (83.0% of those who were interested already used EE/EC or RE). Only a small number of those who used EE/EC or RE indicated that they had no interest in future implementation (5.1% of those who were using EE/EC or RE).

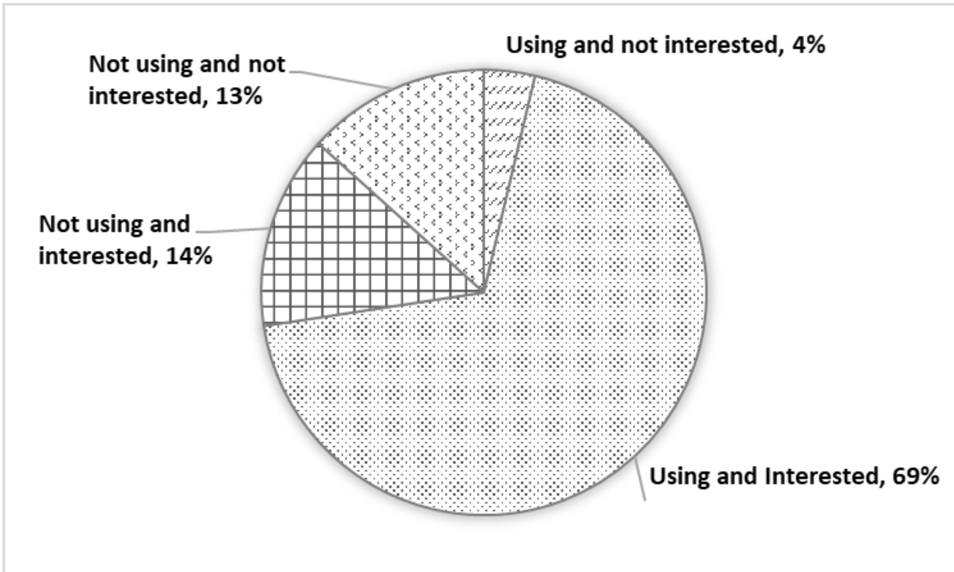

Figure 4.1 Percentage of registered NS farmers using versus interested in using EE/E and RE

Many energy options were of interest to farmers including lighting, behaviour options, wind, and efficient vehicles (Table 4.1). However, when asked to pick one energy option that was of most interest, RE options came out on top with almost 78% of farmers picking a RE option. Wind and solar water were the energy options that received the most interest (22.8% and 18.1% respectively). This may be because of a high uptake in EE/EC implementation prior to 2012. 68.9% of NS farmers made an EE/EC upgrade on the farm between 2007 and 2012 compared to 28.2% of NS farmers who made a RE upgrade (including wood) in the same period (Bailey *et al.,* 2016).

Table 4.1 Level of NS farm interest to implement future EE/EC and RE options

EE/EC Options of interest	Interest %	RE Options of interest	Interest %
Lighting	40.4	Wind	38.1
Behaviour	36.3	Solar water	33.0
Efficient Vehicle	29.3	PV	25.6
Techniques (i.e. no till)	28.9	Passive solar	23.0
Insulation	27.8	GSHP	14.8

EE/EC Options of interest	Interest %	RE Options of interest	Interest %
Windows	22.2	ASHP	13.3
Efficient Motors	20.4	Solar air	12.2
Natural Ventilation	20.4	Biofuel	11.9
Efficient Furnace	16.7	Ag Biomass	9.3
Heat exchanger/recovery	15.9	Wood	9.3
Efficient Fans	15.6	Leasing land	7.8
Zero-energy waterer	14.1	Hydro	5.2
Thermostat	12.6	Biogas	4.4
VSD	7.0	Tidal	3.0
Other	1.1	Other	2.6

The high interest in RE vs EE/EC may be linked to the visibility of RE technologies. The energy savings from energy efficiency measures can be hidden by increased economic activity, demographic effects, and energy price increases (Ringel *et al.,* 2016). This is true for NS dairy farms which have reduced energy use but have not seen energy cost decreases (Bailey *et al.,* 2016). RE technologies tend to make money rather than save money which is more tangible. Highly visible technologies, like wind power, can be symbolic of sustainable leadership (Building Efficiency Initiative, 2010), allow others to see what has been done, and act as an awareness campaign for those who may be interested. Improving reputation is not a motivator for NS farmers to implement an energy upgrade (Bailey *et al.,* 2018). However, peers, family, and friends are the main influencers for NS farmers when making energy upgrades (Bailey *et al.,* 2018). Therefore, visible technologies act as an information delivery mechanism. This is important in NS where almost one quarter of NS farmers use farm visits as their preferred information delivery mechanism (Bailey *et al.,* 2018). Wind is a highly visible technology and despite its lack of feasibility for small on-farm systems (Mudasser, Yiridoe and Corscadden, 2013), there is still high interest. This points to the need for reliable and accurate information, and informed and available support services.

The high interest in RE vs EE/EC may also be linked to the desire for self-sufficiency. Self-sufficiency and being innovative are significant reasons for NS farmers to implement RE upgrades compared to EE/EC upgrades. The idea of self-reliance is associated with sustainable farming (MacRae, Henning and Hill, 1993), and may resonate with some farmers.

There was considerable change in what NS farmers were interested in implementing in 2012 vs 2005 (Table 4.2). There was a significant increase in interest for passive solar and a marginally significant increase in interest in solar water and PV. Solar air showed no significant change. Compared to the rest of Canada, the Atlantic provinces have higher feasibility potential for solar domestic hot water upgrades due to high energy costs (Nikoofard, Ismet Ugursal and Beausoleil-Morrison, 2014).

Table 4.2 Comparison of expressed interest levels between 2005 and 2012

EE/EC or RE Option	Interest [%]	Difference from 2005 [%]	ρ-Value
Lighting	40.4	-34	0
Wind	38.1	-32	0
Behaviour	36.3	-7	0.571
Solar water	33.0	32	0.071
Techniques	28.9	-4	0.764
Insulation	27.8	-37	0
PV	25.6	42	0.062
Passive solar	23.0	64	0.014
Windows	22.2	-40	0
Heat exchanger/recovery	15.9	-36	0.016
GSHP	14.8	23	0.425
Solar air	12.2	-19	0.422
Wood	9.3	-42	0.035
Leasing land	7.8	56	0.273
Biogas	4.4	-60	0

There was a significant decrease in interest from 2005 to 2012 for lighting, insulation, windows, heat exchange/recovery, wind, wood, and biogas. One could argue that since lighting, insulation, and windows were the top three most implemented EE/EC options between 2005 and 2012 (Bailey *et al.,* 2018), the lack of interest is due to lack of opportunity for future implementation. It is likely that many NS farmers have implemented these options, but since there is still considerable interest, there is still opportunity for those who have only partially implemented or have not yet implemented these energy options (approximately one third, 32.1%, of those interested have not yet implemented efficient lighting options).

The interest in biogas dropped, but since the number of farms that can implement this technology is relatively small, a small change in numbers can look like a large percentage change. Prior to 2012, there was no on-farm biogas implementation in NS. In 2014, a biogas system on a NS dairy farm began generating electricity (Campbell, 2014). Additionally, a centralized biogas facility that utilizes mink farm waste as a feedstock became operational in 2013; electrical generation began in 2015 (Quest Nova Scotia Caucus, 2015). This may be attributed to the NS COMFIT program (Nova Scotia Department of Energy, 2010). The COMFIT program should have improved biogas feasibility, and therefore should have increased interest. Feed-in tariff (FIT) policy encourages RE investment through financial incentive over time (Mosher and Corscadden, 2012). Perhaps the COMFIT program allowed for increased awareness and education on the high capital costs associated with biogas, and therefore the remaining interest could be from those who may be more likely to implement. The interest in wind also decreased and this may be due to feasibility challenges associated with small wind facilities (payback tends to improve with increased wind turbine size) (Mudasser, Yiridoe and Corscadden, 2013); however, it is still the top RE of interest. Additionally, the COMFIT program did include wind but, unlike combined heat and power projects such as biogas, investment had to be via community-based organizations (Nova Scotia Department of Energy, 2011a; Nova Scotia Department of Energy, 2011b). In most cases, a farmer could choose to apply to do a COMFIT biogas project as an individual business, but a COMFIT wind project had additional restrictions on who could apply.

The changes in interest over time may be further explained by applying the theory of diffusion of innovation (Rogers, 2010). This theory proposes five stages of technology adoption (Figure 4.2) (Rogers, 2010). Essentially, over time there may be increased uptake of a particular technology/innovation. Innovators represent 2.5% of the population that can/will adopt a technology and are the first to implement the new technology and are likely young and willing to take risks (Rogers, 2010). Early adopters are the next group to adopt an innovation (13.5%) and tend to be young, educated, and are willing to test out a technology (Rogers, 2010). They are followed by the early majority (34%) who tend to be practical and are waiting for the technology to be proven (Rogers, 2010). The next group is the late majority (34%) who tend to be skeptical about innovation and will adopt it once it is normal to do so (Rogers, 2010). The last group is the laggards (16%) who tend to be older and adverse to change (Rogers, 2010).

Biogas is in its infancy in NS; those that are implementing are innovators and early adopters. At this point there is only a handful of NS farmers interested in this technology. Efficient lighting use, however, is fairly mature in NS and those implementing now are likely the late majority. There is a lot of interest from this large group of potential adopters. However, some types of lighting (compact fluorescent lights, or CFLs) do not function well in cold barn applications and only more recent advancements in light-emitting-diode (LED) lighting have made LED lighting a feasible option (Clarke and House, 2006; Alberta Department of Agriculture and Forestry, 2016). Therefore, these lighting applications are gaining in popularity and NS farmers are likely in the early adopter/early majority stage.

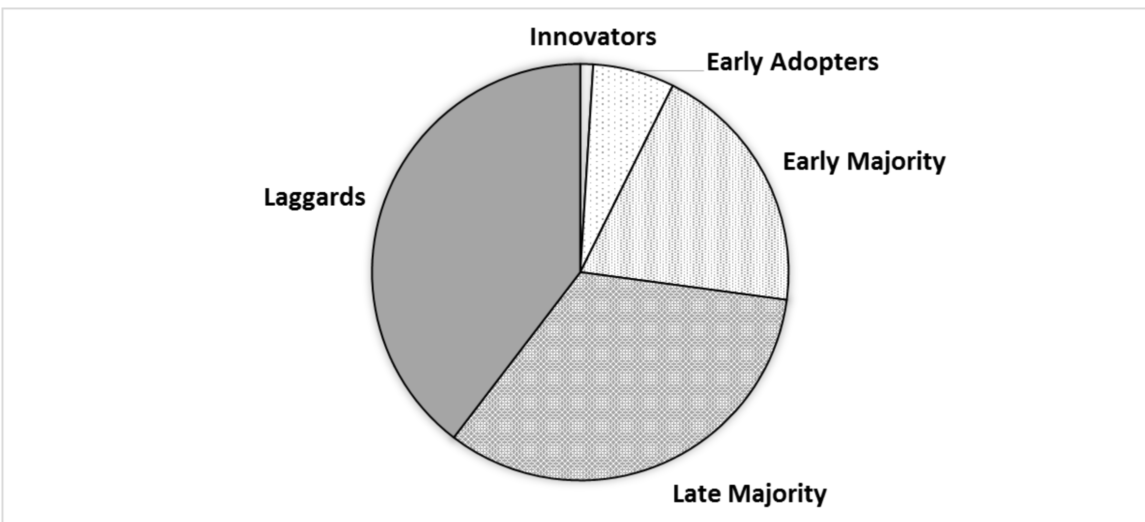

Figure 4.2 Five Stages of Technology Adoption from Diffusion of Innovation (Rogers, 2010).

4.3.3 Opportunity areas by farm type

Opportunities are presented by farm type for dairy, beef, and poultry operations. These farm types were selected for more detailed analysis since, in NS, dairy and poultry have the highest energy expenses (Bailey *et al.,* 2016) and beef operations have the highest number of farms (Mahoney, 2012).

4.3.3.1 DAIRY

Dairy is the agricultural commodity in NS with the highest farm cash receipts (Thibodeau, 2014). They also have some of the highest energy bills compared to other farm types in NS (Bailey, Gordon *et al.,* 2008). NS dairy farms have seen a trend of increasing farm size and a decreasing number of farms (Bailey *et al.,* 2016; Statistics Canada, 2012c; Devanney and Reinhardt, 2011). This allows for increased efficiency with economies of scale. Unfortunately, due to increases in energy pricing, NS dairy farmers have not seen a decrease in their energy bills despite significant energy reductions from EE/EC and RE implementation (Bailey *et al.,* 2016; Bailey *et al.,* 2018). NS dairy farmers have not been discouraged and show high interest in EE/EC and RE implementation. Survey results from 2012 show that 94.2% ± 6.4% of NS dairy farms indicated they were interested in implementing an EE/EC or RE upgrade in the next five years (82.7% were interested in an EE/EC upgrade and 80.8% were interested in a RE upgrade).

Lighting, variable speed drives, efficient motors, zero-energy waterers, and natural ventilation are some examples of EE/EC technologies that can be used on dairy farms. Survey results show that lighting and natural ventilation are the EE/EC upgrades most often used, followed by heat exchanger (i.e. plate cooler), insulation and heat recovery (i.e. heat reclaimer) (Table 4.3). These upgrades have resulted in a 57.2% reduction in electricity use per cwt of milk produced (Bailey *et al.,* 2016).

Table 4.3 Percentage of NS dairy farms implementing EE/EC and RE upgrades between 2007 and 2012 and those interested in future implementation, sorted by interest level (highest to lowest)

EE/EC Option	Used [%]	Interest [%]	RE Option	Used [%]	Interest [%]
Lighting	69.2	53.8	Wind	3.8	50.0
Natural ventilation	61.5	38.5	Solar water	1.9	44.2
Motors	21.2	36.5	PV	1.9	19.2
Fans	21.2	34.6	GSHP	1.9	19.2
Vehicle	7.7	34.6	ASHP	3.8	17.3
Heat exchanger	44.2	*28.8	Passive solar	0	15.4
Heat recovery	40.4	*28.8	Biofuel	2.3	11.5
Insulation	42.3	21.2	Ag Biomass	3.8	11.5
Windows	19.2	21.2	Biogas	0	9.6
Zero energy water	21.6	19.2	Solar air	0	7.7
Variable speed drive	15.4	19.2	Hydro	0	7.7
Furnace	9.6	13.5	Wood	3.8	3.8
Thermostat	11.5	11.5	Tidal	0	1.9

*heat recovery and heat exchanger were combined in the survey when asking interest.

The survey showed that lighting is the most utilized EE/EC upgrade on dairy farms with 69.2% of farmers upgrading to some form of efficient lighting (Table 4.3). This is not surprising given the targeted efficient lighting programming in NS (Efficiency Nova Scotia Corporation, 2013b). However, this response does not explain to what extent the lighting has been replaced on the farm. Therefore, it is likely that there are still some farms with opportunity for efficient lighting. This was confirmed through 21 dairy site visits conducted by me (as the FES) in the spring of 2012. These visits showed that 86% of the sites had some efficient lighting (typically CFLs and/or HPT8), but 67% still had some inefficient lighting (i.e. incandescent and/or T12). A previous survey, in 2005, showed that 79.0% of dairy farmers used efficient lighting (Bailey *et al.,* 2008). It is likely that farmers who used some form of efficient lighting in 2005 have continued to upgrade their lighting throughout their operation. It is also likely that dairy farmers who used only inefficient lighting in 2005 have continued to do so. This is further confirmed when comparing interest levels and implementation; only 19.1% of the farmers not using efficient lighting were interested in a lighting upgrade in the next five years. The bulk of the interest was from farmers who already have some efficient lighting on their farm.

Heat reclaimers and plate coolers are two technologies used on dairy farms that can result in significant energy savings, especially since approximately 44% of electricity used on NS dairy farms is associated with milk cooling and water heating (Corscadden, Biggs and Pradhanang, 2014; Farm Energy Nova Scotia, 2010). However, these technologies do not operate independently of each other since having a plate cooler reduces compressor runtime, and therefore reduces the benefit of the heat reclaimer (Farm Energy Nova Scotia, 2010). However, for farms with more than 4000 hl of annual production (approximately 50 dairy cows using the 78 hl/cow Canadian average), the combined energy savings make it worthwhile to have both technologies (Canadian Dairy Commission, 2015; Corscadden, Biggs and Pradhanang, 2014). For farms producing less than 4000 hl/year, a heat reclaimer provides the most energy savings (Corscadden, Biggs and Pradhanang, 2014). The average dairy farm in NS would benefit from using both a heat reclaimer and a plate cooler (Statistics Canada, 2012c).

Survey results show that 28.8% of NS dairy farmers upgraded to have both a heat reclaimer and plate cooler, and 26.9% upgraded by adding one or the other. Large and very large farms were more likely to install both, while other farm sizes are more likely to install neither; 65.2% of farms with GFR <$500,000 did not implement a heat reclaimer or plate cooler upgrade. The 2011 census reported that 33.5 % of dairy farmers in NS are very large (Statistics Canada, 2013). These farms would produce more than 4000 hl/year and should consider having both technologies. There are several large farms ($100,000< GFR< $500,000) that would produce more than 4000hl/year as well and should consider using both technologies. The 2005 survey showed that 42% of NS dairy farms used heat recovery equipment (Bailey *et al.,* 2008), and this present study showed that 40.4% of NS dairy farms implemented a heat recovery upgrade between 2007 and 2012 (Bailey *et al.,* 2018; Corscadden, Biggs and Pradhanang, 2014). This means that many NS dairy farms have a heat reclaimer, but since all NS dairy farms would benefit from heat recovery (Corscadden, Biggs and Pradhanang, 2014), there is like still some opportunity. This was confirmed through 21 dairy site visits conducted by me in the spring of 2012. These visits showed that 67% of the sites had a heat reclaimer, 57% had a plate cooler, 33% did not have a heat reclaimer but would benefit from one, and 19% did not have a plate cooler but would benefit from one.

It is worth noting that although efficient vehicle use has the lowest implementation rate of EE/EC options (7.7% of farmers implemented an efficient vehicle upgrade between 2007 and 2012), the effect of current implementation is noticeable. There has been a notable shift away from gasoline use to more efficient diesel use on NS dairy farms (Bailey *et al.,* 2016), as well as, considerable interest in efficient vehicles. However, with minimal programs targeted at transportation fuels due to a focus on electricity reductions (Efficiency Nova Scotia Corporation, 2013a), this points to an area of opportunity for future programming.

When asked to pick one energy option that was of most interest, wind, solar water, and air-source heat pump were most often selected by NS dairy farmers (31.0%, 23.8%, and 9.5% respectively). Solar water technologies are of interest to NS dairy farmers and have a low implementation rate (1.9% implemented between 2007 and 2012). This points to a potential opportunity, especially since hot water use represents approximately 16% of total farm electricity use (Corscadden, Biggs and Pradhanang, 2014).

Almost 10% of NS dairy farms are interested in Biogas. Large dairy operations may have the potential to implement a biogas system. However, these systems can represent high capital investments and as previously mentioned, the COMFIT program should have improved biogas feasibility, and therefore may have increased interest.

4.3.3.2 BEEF

Beef farming represents the largest group of registered farms by farm type (Nova Scotia Department of Agriculture, 2015a). However, there has been a reduction in both the number of registered beef farms, and their size between this study and the 2005 baseline survey (Statistics Canada, 2012c; Mahoney, 2012; Crouse, 2007). Despite the hardships in this sector, there is still interest in EE/EC and RE with 65.9% ± 1.5% of registered NS beef farmers interested EE/EC or RE (50.0% in EE/EC, 61.4% in RE).

Lighting is the most utilized EE/EC upgrade on beef farms in NS with 34.1% of farmers upgrading to some form of efficient lighting (Table 4.4). This is not surprising given the targeted efficient lighting programming in NS (Bailey, 2010; MacPherson, 2009). However, this response does not explain to what extent the lighting has been replaced on the farm. Therefore, it is likely that there are still some farms with opportunity for additional efficient lighting. This was confirmed through 10 beef site visits I conducted in the spring of 2012. These visits showed that 50% of the sites had some efficient lighting (i.e. CFLs), but 90% still had some inefficient lighting (i.e. incandescent or T12s). When comparing interest levels and implementation, only 9.1% of beef farmers not using efficient lighting were interested in a future lighting upgrade. The majority (60%) of the interest in lighting upgrades comes from farmers who are already using some efficient lighting.

The previous survey from 2005 showed that 58% of NS beef farmers used efficient lighting (to some extent) and 65% were interested (Bailey *et al.,* 2008). In 2012, implementation increased and interest decreased. Despite this, opportunities exist in areas where previous technologies were not functional. For example, outdoor areas (i.e. cold barn environments) may not be suitable for compact fluorescent lights (CFLs) as they take time to reach full brightness in cold conditions (Clarke and House, 2006). This is a deterrent for implementation on beef operations. However, since then, LED technologies have dropped in price and can offer the functionality the CFLs could not (Alberta Department of Agriculture and Forestry, 2016). This means that the opportunity for lighting upgrades on beef farms likely exists with the laggards (the <10% who have not implemented efficient lighting but have interest) and with those who have partially implemented but have outdoor/barn/cold environment applications that were problematic in the past for CFL installations. A program targeting the benefits of LED technologies for outdoor/barn/cold environment applications could have a reach beyond beef farms and be applicable to other livestock operations such as dairy, sheep, and even non-livestock facilities with storage/barn spaces.

Table 4.4 Percentage of NS beef farms implementing EE/EC and RE upgrades between 2007 and 2012 and those interested in future implementation, sorted by interest level (highest to lowest)

EE/EC Option	Used [%]	Interest [%]	RE Option	Used [%]	Interest [%]
Lighting	34.1	22.7	Wind	2.3	36.4
Insulation	15.9	22.7	PV	20.5	27.3
Vehicle	4.5	22.7	Solar water	4.5	18.2
Zero energy water	6.8	20.5	Passive solar	4.5	18.2
Natural ventilation	13.6	11.4	ASHP	2.3	15.9
Heat exchanger	2.3	*11.4	Biofuel	2.3	15.9
Heat recovery	2.3	*11.4	Wood	9.1	15.9
Thermostat	6.8	11.4	Ag Biomass	2.3	11.4
Furnace	6.8	11.4	Hydro	0	11.4
Windows	13.6	9.1	GSHP	4.5	9.1
Motors	4.5	4.5	Solar air	2.3	9.1
Fans	0	2.3	Biogas	0	4.5
Variable speed drive	0	2.3	Tidal	0	2.3

Zero-energy waterers and efficient vehicles have not been widely implemented but they are among the EE/EC technologies of greatest interest to NS beef farmers. Implementation of these technologies can be problematic for diverse reasons. Efficient vehicles tend to have high capital costs; however, predictions over the next several years show little increase in capital costs and large increases in fuel economy, thus allowing efficient vehicles to be cost competitive vs standard vehicles (Chase and Maples, 2014). Zero-energy waterers are not practical when there is low usage (Thomas, 2014).

When asked to pick one energy option that was of most interest wind, air-source heat pump, biofuels, PV, and solar water were the most often selected by NS beef farmers (18.2%, 13.6%, 13.6%, 9.1%, 9.1% respectively). PV use is the highest on beef farms compared to other farm types (20.5% implemented a PV system between 2007 and 2012). PV systems are often used in remote situations such as fencing or livestock watering where accessibility to an electricity source is problematic (Soil and Crop Improvement Association of Nova Scotia, 2006).

4.3.3.3 POULTRY

Improved energy efficiency on NS poultry operations can have a significant financial benefit, especially since NS poultry farms have the highest energy bills compared to other farm types in NS (Bailey *et al.,* 2016). Survey results show increased energy efficiency on NS poultry farms. However, this has not resulted in decreased electricity expenses due to increases in pricing and inflation. This means that NS poultry farmers have prevented their energy bills from increasing dramatically over time but may not see a reduction when looking at costs alone. There is continued interest with 100% of NS poultry farmers indicating interest in future implementation of an EE/EC or RE upgrade on the farm (85.7% ± 17.3% were interested in an EE/EC upgrade with the same interest in a RE upgrade).

Lighting, insulation, and efficient motors and fans are some examples of EE/EC technologies that can be used on poultry farms. Survey results show that lighting and insulation are the EE/EC upgrades most often used, followed by efficient motors and fans (Table 4.5). Upgrades have resulted in a 30% reduction in electricity use as well as reductions in oil, gasoline, and diesel use (Bailey *et al.,* 2016). Opportunities exist in these areas due to continued interest in these technologies.

Table 4.5 Percentage of NS poultry farms implementing EE/EC and RE upgrades between 2007 and 2012 and those interested in future implementation, sorted by interest level (highest to lowest)

EE/EC Option	Used [%]	Interest [%]	RE Option	Used [%]	Interest [%]
Lighting	71.4	78.6	Solar water	14.3	50.0
Insulation	71.4	50.0	Wind	0	42.9
Fans	35.7	42.9	PV	0	35.7
Motors	42.9	42.9	Passive solar	0	28.6
Windows	28.6	35.7	GSHP	35.7	14.3
Heat exchanger	7.1	*28.6	ASHP	14.3	14.3
Heat recovery	0	*28.6	Biofuel	0	14.3
Thermostat	14.3	21.4	Ag Biomass	0	14.3
Vehicle	21.4	21.4	Solar air	0	14.3
Natural ventilation	14.3	14.3	Wood	7.1	14.3
Variable speed drive	0	14.3	Biogas	0	7.1
Furnace	28.6	14.3	Hydro	4.8	7.1
Zero energy water	7.1	7.1	Tidal	0	7.1

The survey showed that ground-source heat pumps (GSHP), air-source heat pumps (ASHP), and solar water were the top three implemented RE upgrades on NS poultry farms. A solar air project was implemented on a poultry farm in 2010, although this is not shown in the survey results (Nova Scotia Federation of Agriculture, 2012c). When asked to pick one energy option that was of most interest, solar water, wind, and agricultural biomass were the most often selected by NS poultry farmers (28.6%, 21.4% and 14.3% respectively).

4.4 Conclusion

There continue to be many opportunities for NS farmers to implement EE/EC and RE options. Efficiency programming has likely captured the innovators, early adopters, and the early majority for some EE/EC options (50% of potential adopters), including lighting. EE/EC and RE opportunities still exist in NS as there is no indication that NS farmers have completed the late majority stage on any EE/E or RE options (50%< and <84% adoption). Except for a few sector-specific examples, RE options are at the innovator and early adopter stages (<16% adoption). PV for beef and GSHP for poultry have higher implementation and are likely in the early majority stage (16%< and <50%). That means there are still many more farmers who can make upgrades.

The past energy policies and programs, and the many farmers who now exist as examples to others, may help carry the momentum forward and result in more implementation and future energy savings. However, there is still a need for support. Those who received support (e.g. energy audit) were more likely to implement or be interested in implementing (Bailey *et al.,* 2018). However, support for on-farm decisions on technology options is based primarily on a cost-benefit analysis without evaluating which technologies are more or less sustainable. The next chapter presents an application of a framework to help farmers navigate the complexities of sustainability and help transition towards more sustainable energy choices. In general, a conceptual framework can provide a basic understanding of sustainability with the goal of reviewing economic, social, and environmental impacts, promoting a logical assessment of those impacts and better priority-setting of options. The framework presented in the next chapter will encourage more thoughtful decision-making and encourage a more carefully considered analysis of *all* of the costs and benefits.

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CHAPTER 5 A FRAMEWORK FOR ENERGY SUSTAINABILITY IN AGRICULTURE, WITH APPLICATIONS TO FARMS IN NOVA SCOTIA, CANADA

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In Preparation

5.1 ABSTRACT

Energy sustainability relates to affordability, equity, and efficiency of energy sources, as well as efficient energy use, energy security, and environmental sustainability. Social, economic, and environmental elements are all critical for decision-making dedicated to the pursuit of sustainability. However, decision-making support for energy choices (e.g. energy audits) often focus on economic considerations only. Conceptual frameworks exist for incorporating sustainability considerations into decision-making but none links sustainability to energy decisions at the level of the small enterprise. This paper presents a framework for energy sustainability in agriculture (FESA) developed to bring systematic thinking into the decision-making process to improve farm energy management. FESA was developed and validated using multiple methods: interviews, surveys, observations, and case studies on the Nova Scotia agricultural sector. FESA has been built by incorporating elements of other robust frameworks related to the pursuit of sustainability. It uses a management system approach to promote continual improvement and consideration of environmental and social priorities, not just economics, when exploring energy upgrades. It provides a series of steps that can be followed by farmers, and energy professionals providing support services, for energy-related projects on the farm in Canada and beyond.

5.2 KEYWORDS

Energy Management; Agriculture; Decision-Making Process; Framework

5.3 INTRODUCTION

Social, economic, and environmental elements are all critical for decision-making dedicated to the pursuit of sustainability. Energy sustainability has been described as affordable and equitable access to efficiently produced and distributed energy, as well as efficient use of energy resources, a secure energy supply, and ensuring environmental sustainability (Canadian International Development Agency, 2002). The three so-called pillars of sustainability should be considered when evaluating energy systems (Buchholz *et al.,* 2009):

1) Environment: reducing undesirable ecological effects of the energy supply chain and inefficient energy use (e.g. air pollution, GHG emissions, natural resource depletion)
2) Economic: reducing energy dependence and generating business and wealth (e.g. increasing local business development)
3) Social: improving social conditions (e.g. human health, job creation, and stakeholder involvement in decision-making).

Major developments have occurred over the past decade in Nova Scotia (NS) in relation to environmental sustainability goals for clean energy, climate change, healthy air and water, leadership in sustainable practices, protection of biodiversity, and sustainable management of natural assets (Province of Nova Scotia, 2017). The clean energy goals, with a focus on energy sustainability, support a transition to sustainable uses of energy and cleaner energy sources (Province of Nova Scotia, 2017). Measurable progress is evident; for example in 2015, more than 26% of total electricity produced in NS was from renewable sources compared to 10% in 2006 (Province of Nova Scotia, 2008; Province of Nova Scotia, 2017).

A key facet of farm sustainability is energy use. The agricultural community in NS has been implementing energy conservation methods and renewable energy options to improve their financial performance (Bailey *et al.,* 2018). Mitigating energy price increases through conservation and renewable energy options can help farmers remain competitive. Many of these options are consistent with the concept of energy sustainability. Energy audits are one tool used to evaluate energy options. This type of tool supports on-farm decision-making based on economic considerations. So far, little consideration or support has been directed toward incorporating the environmental and social dimensions into energy choices (American Society of Agricultural and Biological Engineers, 2015). On-farm decisions on technology options are based primarily on monetary cost-benefit analysis without evaluating environmental or social factors. It is often much easier to focus on the economics since farm operating costs associated with energy can be easily quantified. The costs and savings associated with best management practices and energy conservation choices can be quantified and communicated to the farmer (American Society of Agricultural and Biological Engineers, 2015). Incorporating only financial cost-benefit analysis while relying on "objective" experts may lead to project failure (Buchholz *et al.,* 2009). Although cost-benefit analysis is a fundamental component of energy management on the farm, environmental and social issues must also be part of the sustainability equation.

Measuring sustainability is a complex problem that requires analyzing multiple criteria (Marques *et al.,* 2009). Frameworks can help capture and visualize trade-offs among criteria and help move towards sustainability (Alkan Olsson *et al.,* 2009; MacDonald, 2005). Using a framework can help establish key values, assumptions, goals, and definitions. Conceptual frameworks exist for incorporating sustainability considerations into decision-making. Unfortunately, the wide range of tools, frameworks, strategies, approaches, indicators, principles, and processes that pertain to sustainability assessment can lead to confusion for farmers and their advisors (Missimer *et al.,* 2010; MacDonald, 2005).

A framework can help identify solutions that offer the greatest potential to assist in the transition towards sustainability (MacRae, Henning and Hill, 1993). Whatever definition or conception of sustainability is adopted to guide framework development will shape the scope and content (MacRae, Henning and Hill, 1993). Existing frameworks may not be appropriate for on-farm energy decision-making in NS as none links sustainability to energy decisions at the small enterprise level. The conceptual foundations of ES as they apply to NS farming operations and energy choices on the farm must be defined to guide framework development. Application of a framework should help farmers navigate the complexities of sustainability and help transition towards more-sustainable energy choices. A framework will provide a basic understanding of sustainability and promote both a logical assessment of diverse impacts and better priority-setting of options. A framework can include critical supportive policies, programs, and regulations, feasible time frames, and institutions and groups involved in implementation (Missimer *et al.,* 2010). It can demand a more careful analysis of *all* the costs and benefits and thus lead to more thoughtful decision-making.

The research reported in this paper focuses on incorporating energy sustainability into farm decision-making when selecting energy conservation and generation options. The main goal of the research is to develop and test a framework that can help in the decision-making process to improve farm energy management. The two main objectives of the framework are to:

1. drive on-farm energy decision-making through a systematic consideration of all facets of sustainability.
2. instil a process of continual improvement in farm energy management.

The framework has been created by reviewing literature, interviewing NS farmers and North American energy professionals, surveying NS farmers, observing on-farm energy improvements in NS, and two case studies of NS farms. The framework itself is made up of a general concept and a series of specific steps that can be followed to assist in energy management on the farm.

5.3.1 Framework concept

The starting point for a framework for energy sustainability in agriculture (FESA) is the notion that farm-scale transition to sustainable practices involves three overlapping stages: efficiency, substitution, and redesign (ESR) (Macrae, Lynch and Martin, 2010; Hill and MacRae, 1996). Although the ESR model has been proposed for whole-farm management (e.g. animal management, manure management, crop design) (Macrae, Lynch and Martin, 2010; Hill and MacRae, 1996), for our purposes it is applied to on-farm energy management. The stages go from simple to complex. The efficiency stage reduces energy waste (often minor changes to existing practices), the substitution stage replaces or augments practices/technologies, and the redesign stage reviews entire processes to achieve larger improvements, thus taking longer to implement (Hill and MacRae, 1996). ESR has been proposed for pest management (Lamine *et al.,* 2010; Hill, Vincent and Chouinard, 1999), and energy efficiency and greenhouse-gas mitigation on organic farms (Macrae, Lynch and Martin, 2010). The approach is also well suited to farm energy projects.

The ISO 50001 standards provide a framework for organizations to set up, and continually improve, energy management (International Organization for Standardization, 2017). It is based on the Plan-Do-Check-Act (PDCA) cycle and integrates both technical and managerial activities (Natural Resources Canada, 2016). The ISO 50001 framework requires the following (International Organization for Standardization, 2017):

- Developing a policy for more efficient energy use
- Setting targets and objectives to meet the policy
- Using data to understand and make decisions
- Measuring results
- Reviewing effectiveness of the policy
- Continually improving

The PDCA cycle applies not just to decision-making but more broadly as the continuous improvement loop for a management system. This approach allows for better integration into farm management and planning rather than a one-time decision.

The Framework for Sustainable Agriculture (FSA) is a continuous improvement framework that proposes the minimum criteria for developing and implementing a program for sustainable agriculture (American Society of Agricultural and Biological Engineers, 2016). It has adapted and simplified the PDCA cycle into three actions:

define, plan, and implement (American Society of Agricultural and Biological Engineers, 2016). These actions each have sub-elements, such as defining sustainability goals, defining indicators, developing a strategy to meet goals, benchmarking, implementing, measuring, and adapting (American Society of Agricultural and Biological Engineers, 2016). The framework also suggests utilizing multi-stakeholder engagement (American Society of Agricultural and Biological Engineers, 2016).

Stakeholder inclusion has been highlighted in some conceptual frameworks. Whitton et al. (Whitton *et al.,* 2015) developed a conceptual framework for social sustainability of energy infrastructure projects to improve social acceptability of energy projects and included stakeholder workshops to identify priorities and desirable outcomes. Adaptive management is another framework that involves bringing stakeholders together and involves steps such as planning, choosing, implementing, checking and revisiting (Duinker and Trevisan, 2003). Adaptive management is a broadly recursive process (Duinker and Trevisan, 2003). It is a problem-solving approach designed for natural resource sectors such as forestry, fisheries, and agriculture (Duinker and Trevisan, 2003; Stankey, Clark and Bormann, 2005; Bormann, Haynes and Martin, 2007).

The Canadian Standards Association has a national standard for sustainable forest management (SFM) (Canadian Standards Association, 2002). This standard specifies a process for defining sustainability objectives and indicators. It provides a good outline for examining values and the development of indicators from these: value, objective, indicator, and target (VOIT). The relationships among values, objectives, indicators, and targets are strictly laid out with unambiguous definition (Figure 5.1).

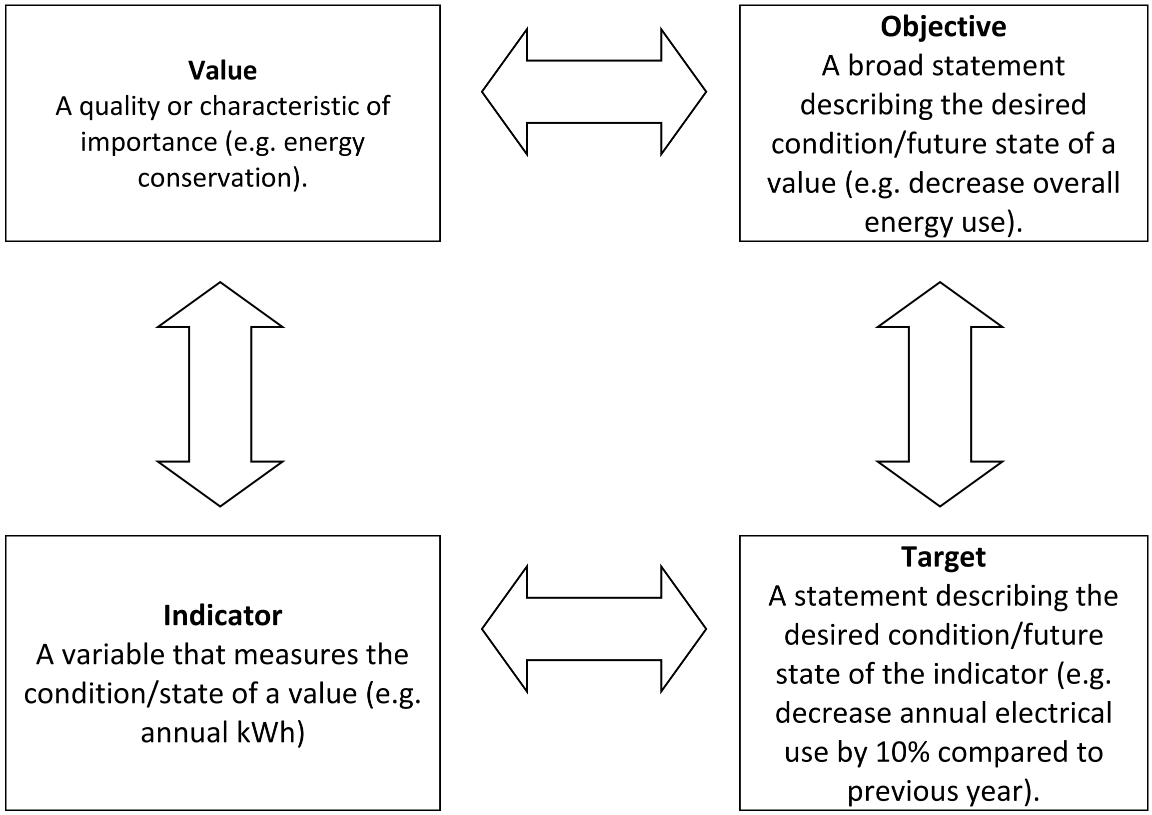

Figure 5.1 VOIT Diagram adapted from the Canadian Standards Association (Canadian Standards Association, 2002)

Our research has built upon existing frameworks and standards such as ESR, FSA, VOIT, and ISO 50001 to propose a new framework for on-farm energy decision-making. Creativity is essential for research of complex and multivariate phenomena and for engineering problem-solving (Loehle, 1990; Cropley, 2015). While routine problem-solving uses traditional and well-established methods, creative problem-solving integrates new solutions with existing or new needs/problems and can bring about innovation (Cropley, 2015). Also, integrative thinking was essential in the creation of this framework to facilitate the creative resolution of competing models, and develop a new model through the consideration the problem as a whole, rather than its parts (Rothman School of Management, 2008). The standards and frameworks described above have been adapted to the farm level to create FESA. It calls for all efficiency, substitution, and redesign projects (ESR framework) to follow three steps (FSA framework): 1) define values, objectives, indicators, and targets (define VOIT), 2) develop a strategy to meet the targets (plan), and 3) implement. The framework concept shows that the PDCA cycle is active in each type of ESR project (Figure 5.2). The FESA concept is further developed into a series of steps in the following sections.

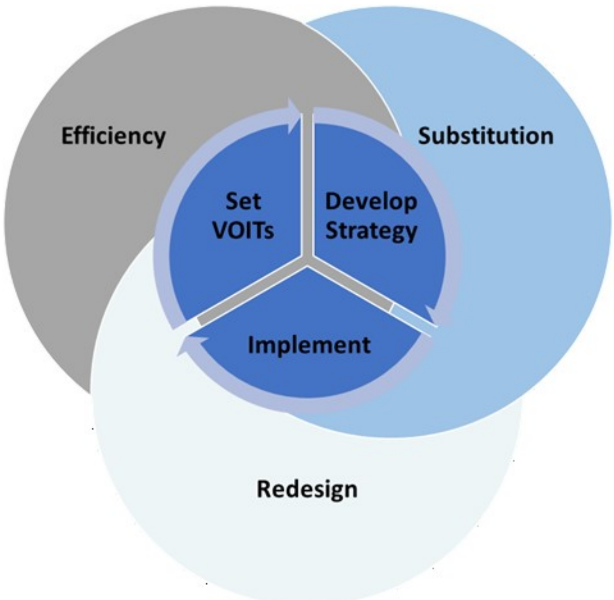

Figure 5.2 FESA concept

5.4 METHODS

Multiple methods have been used to establish credibility and validity of our results: interviews, a survey, observations of energy technologies used gained from farm visits, and case studies (Turner, Cardinal and Burton, 2017; Heesen, Bright and Zucker, 2016). Interviews were done to identify criteria used for on-farm energy decision-making. The survey was designed to collect additional information on criteria used for on-farm energy decision-making and to validate the criteria identified in the previous interviews. Farm visits were used to collect data on energy technologies implemented. The interviews, survey, and observations helped in the development of the framework. The case studies were used to validate the framework.

5.4.1 Interviews

Interviews were conducted between November 2011 and January 2012. The interviews were designed to collect information on criteria used for on-farm energy decision-making. The interview questions also allowed for the identification of barriers to opportunities for implementing energy sustainability options given existing agriculture/energy policies. Ten interviews were conducted on each of two populations: NS farmers who had implemented an energy improvement in the three years prior to the interview, and North American energy professionals with experience conducting on-farm energy audits. These populations were chosen to yield insights from those who inform energy decisions and those who make them. The sample size was determined to ensure adequate capturing of views associated with a range of business types and sizes. The sampling was purposive, and individuals were identified by the lead author, who served as the Farm Energy Specialist (FES) with the NS Department of Agriculture from 2007 to 2012. The interviews identified the following types of information used in the survey design: reasons for implementing energy conservation (EC), energy efficiency (EE) and renewable energy (RE), reasons for considering alternatives when selecting EC/EE and RE upgrades, types of support used for energy decisions, information delivery mechanisms, and obstacles encountered.

5.4.2 Survey

A mail survey of 2393 members of the Nova Scotia Federation of Agriculture (NSFA) was conducted in April 2012 and repeated in November 2012. Response rate varied among farm types, with an overall response rate of 11.4%. This was lower than expected based on a previous survey in 2005 with a 32% response rate (Bailey, Gordon *et al.,* 2008). Typical mail questionnaires receive anywhere from 10% to 50% response rates (Weisberg, Krosnick and Bowen, 1996). The NSFA mail list was used as the sample frame. This is considered representative of the entire registered farm population since all registered farms are also NSFA members (Nova Scotia Department of Agriculture, 2015a). Farm registration is voluntary and there is an annual fee (Nova Scotia Department of Agriculture, 2015a). Farms must be registered to access government agricultural programs and additionally, annual gross farm receipts (GFR) must be

>$10,000 (except for new registrants) to access many of these programs (Nova Scotia Department of Agriculture, 2015b). Compared to the census, there are fewer farms in the <$10,000 annual GFR category that are registered (Statistics Canada, 2012d). Although the sample frame captures all registered farms, it does not capture all farms in NS.

The survey was divided into five sections (A to E) each with a unique objective. The first section (A) was designed to gather demographic information such as farm type, farmer age, and farm income as well as basic information on energy use and energy concerns. The second section (B) was designed to gather information on EC and EE options used on the farm and the decision-making criteria used to choose these options. Questions were asked on what energy options were used on the farm, reasons for looking at or implementing alternatives, if anyone influenced the decision, where the respondents went for information, and obstacles they may have encountered. The third section (C) was identical to section B except it was about RE options and farmers were asked what energy source they replaced, offset, or supplemented. The fourth section (D) was about future changes. Questions were asked about the EC/EE and RE options farmers were interested in using, what would influence their decision to implement, when they planned on retiring, and plans for the farm after their retirement. The fifth and final section (E) was a space for comments and ideas.

To verify that the results were representative of NS farms, the surveyed distribution of age ranges was compared to the 2011 Agricultural Census (Statistics Canada, 2012d). There were no significant differences using the Chi-Square Goodness-of-Fit test ($p = 0.745$). There were significant differences when comparing the GFR distribution to the 2011 Agricultural Census ($p=0$). The survey had fewer farmers with GFRs <$10,000 than expected. The differences in GFR distribution may be associated with the use of NS Farm Registration for the sample frame. There were 1603 more farmers listed in the census than those registered. Therefore, this category is underrepresented in the survey results. However, given that age distribution is representative, it is likely that the survey responses are representative of registered NS farmers, rather than all NS farmers.

Predictive Analytics Software (PASW V.17) and Minitab (V.17) were used to analyze the collected data (IBM Corp, 2013; Minitab Inc., 2013). Confidence intervals (CI) were calculated at the 95% confidence level. The two-proportion test was used at the 0.05 significance level (Moore and McCabe, 2006).

5.4.3 Observations

Between 2007 and 2012, the lead author (as FES) completed 162 assessments and 29 energy audits on farms in NS, and data and observations from these were used in this research. Each assessment was either:

1. a Level 1 audit: a walk-through of the farm with an indication of what energy options were suited to the operation with a qualitative indication of potential savings (no formal report) (Thumann and Younger, 2003); or
2. energy-related work for the farmer that involved a site visit or engineering calculations.

The audit was either:

1. a Level 2 audit: a written report including a detailed inventory of equipment, estimated energy usage, comparison of audit data to energy billing, and a quantitative measure of potential savings (Thumann and Younger, 2003).
2. a Level 3 audit: work that went beyond a level 2 audit and included an estimate of energy use based on measurement rather than inventory (actual energy use was measured with equipment) (Thumann and Younger, 2003).

5.4.4 Case Studies

The case studies were conducted in June 2017. The sample population was registered NS farmers who had made a substantial energy improvement after 2007. The sampling was purposive and included two farms that has been previously visited by the FES. The lead author, as FES, was familiar with these farms and their projects due to multiple site visits and discussions regarding their energy projects as the FES. The case studies were also selected because the energy projects were large and could potentially provide a strong validation of the framework. The case studies included farmer face-to-face interviews conducted on farm by the lead author. Semi-structured interviews were used. An interview guide was followed. The interviews were digitally audio-recorded but not transcribed.

5.5 Results And Discussion

The survey, interviews, and observations were used to help develop FESA as detailed in the following sections. FESA is presented as a series of three steps. Each step includes the following:

- general concepts
- localizing the concepts to NS farms
- approach/methods

Two case studies are used to validate the framework by applying it retrospectively to two large energy projects.

5.5.1 FESA development

FESA was developed to help in the decision-making process to improve farm energy management. It is designed to incorporate energy sustainability considerations into NS farm decision-making when selecting energy conservation and generation options. The framework provides a series of steps that can be followed by farmers and energy professionals providing support services for energy-related projects on the farm.

The planning process is crucial to the success of a project (Serrador, 2014). The framework uses two steps that make up the planning process and work best if done concurrently (Figure 5.3). This circular system (constant feedback) approach (Koberg and Bagnall, 1981) is between step 1 (determine VOITs) and step 2 (develop strategy for achieving targets). Ideally the place to start would be at step 1, but in reality, the farmer may have already triggered the planning process with ideas for energy improvement options (these fall under step 2). Step 3 (Implement) is the action stage; the Do, Check, Act in the PDCA cycle. Step 3 includes implementing the plan, checking on results, and continuous learning (reflecting and adapting). The ESR framework is an overarching guide; energy options identified in the process are sorted by ESR and can help identify the order of implementation.

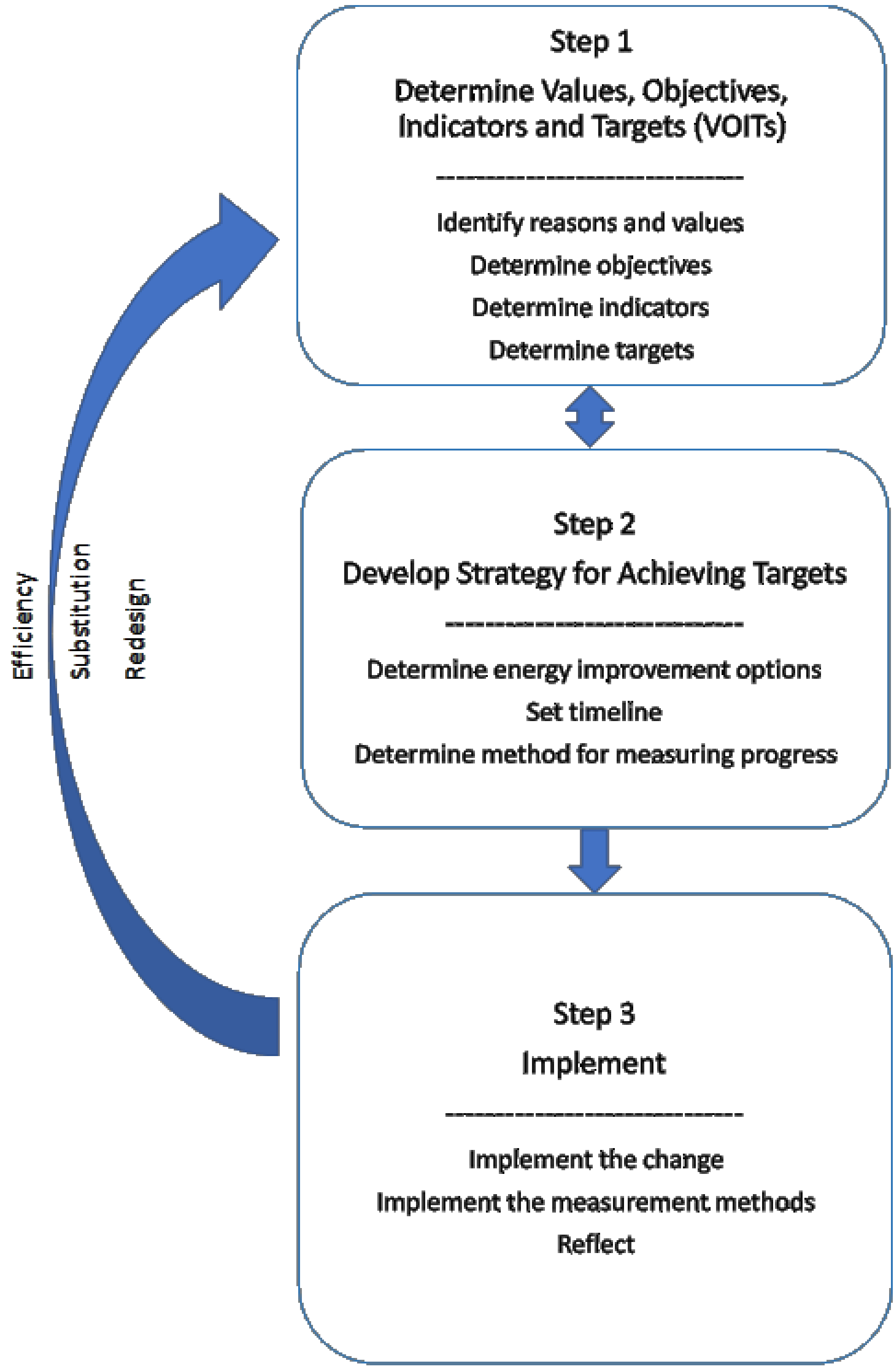

Figure 5.3 FESA Steps

5.5.1.1 DETERMINE VOITS (STEP 1)

Detailed instructions on Step 1 are outlined below.

General concepts

Goal setting involves values and objectives. The CSA SFM standard provides a protocol for identifying values and developing objectives, indicators, and targets (Canadian Standards Association, 2002).

Values are expressions of, or beliefs in, the worth of objects, qualities, or behaviours (Kates, Parris and Leiserowitz, 2005). They are typically expressed in terms of goodness or desirability, or in terms of badness or avoidance (Kates, Parris and Leiserowitz, 2005). For SFM, a value is a characteristic or quality that is deemed important, such as ecosystem diversity or soil quality (Canadian Standards Association, 2002). For energy use in agriculture, values may be energy conservation or self-sufficiency.

Each value needs at least one objective, a broad statement that describes the desired future state or condition for the value (Canadian Standards Association, 2002). It may be possible to have more than one objective for each value but there must be compatibility among the objectives (i.e. mutually supporting objectives) (Canadian Standards Association, 2002).

Indicators should be developed and selected that are measurable and representative of the values. It is important to think about the practicality of indicators as they may be difficult or costly to measure. Data availability is a consideration for selecting indicators. Some indicators may be limited by the availability of relevant and reliable data (Moldan and Dahl,2007). For issues when adequate indicators cannot be found due to missing data or lack of knowledge, proxy indicators can be used (Bauler *et al.,* 2007).

Indicators are important as they sit at the centre of the decision-making process (Meadows, 1998). Therefore, their selection must be systematic and careful. For example, if the number of energy audits completed is chosen as an indicator of potential energy reductions but no one implements energy reduction opportunities from the audits, there may be no reduction in energy use. Although it may be easy to measure the number of audits, this does not measure what was intended.

Once an indicator is developed or selected, a baseline and a target are required to measure progress. The target should be specific and describe the desired future state or condition of the indicator. Targets can be absolute or relative (Bell and Morse, 2003). Changing lights to increase current light level (baseline) to reach a recommended light level (target) is an example of an absolute target. Changing lights to improve a farm's past cost of production (baseline) compared to another farm or an industry average (target) is an example of a relative target.

Localizing the concepts to NS farms

The survey results influenced the decision to use VOIT in FESA. There are many reasons for a farmer to make an energy upgrade. The survey of NS farmers in 2012 showed that saving money and saving energy, as well as self-sufficiency and animal welfare, were typical reasons for NS farmers to implement EE/EC or RE upgrades (Bailey *et al.,* 2018). The desires to be self-sufficient and innovative were also reasons listed by NS farmers when they implemented RE upgrades. These reasons can be used to identify values and set targets relevant to the farm and its stakeholders. For example, valuing self-sufficiency could translate to the target of eliminating dependence on external energy sources. Valuing innovation may translate to a target of being the first farmer in the province to implement a specific novel technology.

Overall, NS farmers tend to value economics above other value clusters. However, the objective of reducing energy use, or even decreasing power bills, can also be translated into an environmental objective such as air emissions reductions (Table 5.1).

Table 5.1 Examples of NS farmers' energy values, objectives, indicators, and targets

Values *Important characteristic/ quality*	**Objectives** *Desired future state of value*	**Indicators** *Variable to measure the value*	**Targets** *Statement describing desired future condition of an indicator*
Energy conservation	Decrease overall energy use	kWh (annual)	Decrease annual electricity use (compared to previous year's average energy use[1]) by 10%
Energy efficiency	Improve energy efficiency	kWh per unit of production	Meet or exceed published benchmark value for sector[2]
Self-sufficiency	Increase self-sufficiency	Amount of purchased energy or % of total energy used	Decrease the amount of purchased energy by 10% compared to previous year[1]
Innovation	To be innovative	Number of installations in the province (recent data)	Be the first farmer in the province to implement a technology (Install a technology on a farm that no other farm has in NS)
Environment	Reduce air emissions	kWh or volume of fossil fuel converted to tonnes of CO_2	Reduce GHG emissions by 10% compared to previous year's value[1]
Animal welfare	Improve animal welfare	Animal mortality/ morbidity frequency	Reduce animal morbidity by 10% compared to previous year's value[1]
Competitiveness	Keep farming	Cost of production (expenses/unit of product)	Be less than the Industry average cost of production[3] compared to previous year's value[1]

[1] Historical baselines could be yearly or monthly if they are representative of typical operation.
[2] For example, 2.33kWh/cwt for NS dairy and 349kWh/cow for NS beef in 2011 (Bailey *et al.,* 2016).
[3] Cost of production data for Apple, Grape, Cranberry, Sheep and Forages are available from the NS Department of Agriculture (Nova Scotia Department of Agriculture, 2017).

Approach/methods

As previously mentioned, there are many reasons to make an energy upgrade; necessity was one of the top three reasons (Bailey *et al.,* 2018). If the reason is necessity, the farmer may have a good starting point in the planning process. For example, if the lighting system is obsolete, then the planning process can begin with identifying values associated with a lighting upgrade. Identifying values can also be done through brainstorming or discussion or simply listing ideas on what the farmer values with respect to energy. However, starting with the reasons for a farmer to consider an energy improvement should help guide this. Consideration should be given to economic, environmental, and social values although some values may incorporate all three pillars (e.g. resilience). Other examples include:

- Economic: energy conservation, energy efficiency, operating cost stability, farm production, operating cost predictability, local business development.
- Environment: biodiversity, air quality, water quality, waste reduction, natural resource conservation, soil health
- Social: energy security, animal welfare, time flexibility, safety, innovation, reputation, community, job creation.

The impact on stakeholders should be considered. The scope of such consideration should match the scope of the project(s). For example, when sorting projects by ESR (see Step 2), a redesign project may have multiple stakeholders versus only a few or none for an efficiency project.

Objectives should describe the desired future state of values. Indicators should be selected that are measurable and representative of the values. Targets should be specific and describe the desired future condition of an indicator.

Here is a summary of the process to determine VOITs:

1) Identify values:
    a) Identify the reasons for an energy upgrade to be considered.
    b) What does the farmer value with respect to energy?
    c) Consider stakeholders.
2) Determine objectives:
    a) Make a broad statement that describes the desired future state or condition for each value.
3) Determine indicators:
    a) Determine an indicator for each objective that is measurable and representative of the corresponding value.
4) Establish targets:
    a) Determine the desired future condition of each indicator.

5.5.1.2 DEVELOP STRATEGY FOR ACHIEVING TARGETS (STEP 2)

Detailed instructions on Step 2 are outlined below.

General Concepts

Determining energy improvement options, setting the timeline, and determining the method for measuring progress are all crucial elements for step 2 of FESA. There are many ways to determine relevant energy improvement options for farms (e.g. farm visits, funding programs, support services). Regardless of the method, identification of the activity and equipment needed for the energy improvement is needed. For example, if a lighting upgrade is chosen, then determination of components (e.g. timers, fixtures) and evaluation of alternatives (e.g. CFL vs LED) are needed. Farmers can accomplish this with or without support services. Examples of support services that can help identify options include energy audits, equipment reviews, farm visits by a professional, and/or information provided by a professional (Bailey *et al.,* 2016). The most comprehensive of these options is the energy audit. An energy audit is a process to evaluate where a building or facility uses energy and identify opportunities to reduce consumption (Thumann and Younger, 2003). It is a method to quantify savings and opportunities and gather benchmarking data. It can help bridge the gap from interest to implementation and is the suggested method in the framework.

The ESR framework can be used to sort identified energy improvement options. Using ESR can also help determine an appropriate timeline. The efficiency stage of ESR reduces energy use (either overall or per unit of production) by making substantive but minor improvements that typically do not require complicated analysis or high costs (Macrae, Lynch and Martin, 2010). In this approach, efficiency is about improving current inputs and methods (Ikerd, 2009). The substitution stage replaces one option for another (e.g. equipment or energy types) or adds a parallel option (Macrae, Lynch and Martin, 2010). This stage is more complicated than efficiency and involves replacing current inputs and methods with less degrading and destructive alternatives (Ikerd, 2009). An example is using solar water technology to replace oil or electricity use. The redesign stage reorganizes operations to use energy more sustainably to fix systemic problems. For this stage to be most effective, it should involve assessing the whole farm. This stage is the most time-consuming and may require the largest changes (Macrae, Lynch and Martin, 2010). It is meant to address the underlying source of problems by changing structure or functionality of the whole operation (Ikerd, 2009). All stages can overlap and do not have to be considered independently. However, it makes sense for efficiency and substitution to occur in advance of redesign (Ikerd, 2009). A diversity of types of ESR strategies suited to energy sustainability are available (Table 5.2).

Table 5.2 ESR Energy Sustainability Strategies

Farm Level Activity	Efficiency	Substitution	Redesign
Lighting	Turn lights off when not needed	Replace inefficient lighting with efficient options	Design new barn (e.g. fabric roof)
Ventilation	Clean fans, routine maintenance	Install high efficiency fans	Design natural ventilation
Space Heating	Use controls and set points	Install solar water	Evaluate new layout and insulation levels
Transportation	Reduce trips required	Size equipment for task	Relocate operations/buildings

Part of the planning process is determining what change(s) to implement now and those for later. ESR can be used to help determine timing of projects:

- Efficiency: Likely least complicated, easier to implement quickly (typically short term)
- Substitution: Likely more complicated than efficiency (typically medium term)
- Redesign: Likely the most complicated and time consuming (typically long term).

Sorting options by ESR can help with short-, medium-, and long-term planning but factors such as necessity, planned construction or renovation work, and succession planning may also influence timelines.

To determine if an energy improvement has met its targets, it is necessary to gather data for the indicators identified in Step 1. The method for measuring and gathering data needed for the indicators should be determined. For example, there may be multiple farm activities on an electrical meter and it may not be possible to identify energy reductions using the main meter; therefore, it may be necessary to install energy monitoring equipment.

Localizing the concepts to NS farms

Determining energy options best suited to a farming operation is a critical step and has been an area of heightened focus in NS over the past decade (Bailey, 2010). In fact, most NS farmers have made an energy improvement on the farm (Bailey *et al.,* 2016). However, there is still opportunity for more energy improvements and there is definite interest.

Survey results showed that NS farmers who received support were more likely to implement or be interested in implementing energy improvements (Bailey *et al.,* 2016; Bailey *et al.,* 2018). Overall, 36% of NS farmers received some support to help guide their energy decisions (Bailey *et al.,* 2016). However, when looking at the types of support, an energy audit was the only type of support that was significantly related to implementing RE (Bailey *et al.,* 2018). Therefore, energy audits are the suggested method to determine energy improvement options in FESA. Energy audits have become more prevalent in recent years with 410 energy audits completed on NS farms by the end of 2012 compared to only 36 by the end of 2005 (Bailey *et al.,* 2016).

Survey results showed that fewer than half of NS farmers who implemented an energy improvement considered alternatives (Bailey *et al.,* 2018). It also showed that the decision process used by NS farmers when considering energy alternatives seems to be more balanced among the pillars of sustainability compared to the decision process on whether to implement an energy upgrade. This means that in implementing an energy upgrade, a farmer mostly considers monetary aspects, but will consider other aspects (i.e. social and environmental) when comparing alternatives (Bailey *et al.,* 2018).

Farmers planning future renovations or construction projects may already have timelines in mind. Survey results showed that many farmers had done a renovation between 2007 and 2012 (63.4%) and many had also built something new (41.4%). Those who are renovating are significantly more likely to implement EE/EC options (80.0%) and marginally more likely to implement RE (32.4%).

Retirement plans may also play a role in setting timelines. One would think it would be more difficult to convince farmers to make energy changes that provide long-term benefit when they are planning on imminent retirement, especially in Nova Scotia where the average age of a farmer in 2011 was 55.4 years (Statistics Canada, 2012a). This is up from 53.2 years in the 2006 Census and 51 years in the 2001 Census (Statistics Canada, 2007). However, there is no significant relationship between age and RE implementation. There is a marginal relationship between age and EE/EC implementation with younger farmers marginally more likely to implement ($p=0.059$). Succession planning may mitigate the expected trend, as planning for a successor begs a long-term strategy.

Necessity is the third most-used reason of NS farmers in making an EE/EC and RE upgrade (Bailey *et al.,* 2018). This may indicate urgency in setting timelines for energy improvements. Projects that are a necessity may need to be done in advance of others that may be more feasible or better match goals.

The success of an on-farm energy project may be determined largely by whether the farmer is saving money. This can be misleading, especially for NS dairy and poultry operations which have reduced energy use but have seen increases in energy bills due to price increases. This highlights the need for proper measurements that can be used for the indicators and baselines established in Step 1.

Approach/methods

Ideally, an energy audit should be completed to determine potential energy improvement options. An audit standard is available for on-farm audits to provide recommendations for feasible energy options (American Society of Agricultural and Biological Engineers, 2015). However, depending on the VOITs, the assessment criteria may need to be modified from the traditional costs, savings, and payback type of recommendations. Recommendations can be sorted by major farm-level activity (e.g. lighting, ventilation, water heating)(American Society of Agricultural and Biological Engineers, 2015) . They should then be sorted into ESR classes to identify projects that can be completed over the short, medium, and long terms (see Table 5.2).

At this stage of the framework, timelines can include only major elements of projects and can be as simple as planning for which energy options to do this year, next year, and several years from now. The main point of setting timelines is to know when to proceed with the next project; this helps keep the plan relevant and useful. Timelines can be revised as needed. More-detailed project management timelines can be completed in Step 3.

It is important to consider the method to measure indicators. This will depend on the VOITs. In some cases, it may be necessary to set up equipment or a process to measure progress (e.g. energy monitoring equipment, sound monitoring, and light levels). It is also important to think about taking representative data:

- Does the time frame of the sample represent regular operation?
- Are there seasonal or temporal variations?
- Is production consistent?

Here is a summary of the process to develop the strategy for achieving targets:

1) Determine energy improvement options (by completing an energy audit) that best meet targets.
    a) Sort options by major farm-level activity.
    b) Sort options using ESR.
    c) Consider alternatives.
2) Set timeline.
    a) Utilize ESR for short, medium and long-term planning.
3) Determine how to measure indicators.
    a) Identify if monitoring equipment is required.
    b) Develop a process/protocol for data gathering (as needed).

5.5.1.3 Implement (step 3)

Detailed instructions on Step 3 are outlined below.

General Concepts

In FESA, implementing the energy improvement, implementing the measurement methods, and reflection are all crucial elements of Step 3. Implementation of the change is the detailed execution of the energy project. This stage also includes project management (Oxford University Press, 2018).

Implementation of the methods to measure changes will likely involve the installation of monitoring equipment or implementation of a process to monitor the indicators. Types of measurement may include direct measurement and/or analysis of existing information (e.g. utility bills) (Jayaweera, Haeri and Kurnik, 2013). Once data have been collected, they can be used to compare to the expected outcomes. Reflection on changes allows for the identification of problem areas, barriers, successes, lessons learned, and best practices that can be utilized for the next steps or modifications to the current one (if needed).

Localizing the concepts to NS farms

Most NS farmers have implemented an energy-related project on the farm (Bailey *et al.,* 2018). Therefore, they are likely familiar with project management. However, energy projects, especially large projects like redesign projects, may benefit from using a project manager (other than the farmer). Also, survey results suggest that it is necessary to consider the resources that may, or may not, be available for implementation, such as contractors, materials, time, and information (Bailey *et al.,* 2018).

In the world of energy audits and upgrades, measuring indicators is a step that tends to be skipped. Farmers may hire someone to give them a report on what they should do but often do not have the auditor come back to verify if the upgrade met their targets. In general, reflecting on results is likely anecdotal and can be problematic if only energy expenses are used as an indicator, since energy prices fluctuate over time. This is the case for NS dairy and poultry farms. Taking the time to review results with measurable indicators can support proper reflection on project successes and areas of improvement.

The survey showed that most NS farmers interested in future implementation were those who already used EE/EC or RE to some extent. This is good news, as those who have previously implemented are more likely to do so again. This means that not only is there is interest in making future energy upgrades, but there is a good chance of implementation.

Approach/methods

Implementation of the planned improvement involves managing many resources including contractors, vendors, time, money, and labour. This will likely involve substantial communication amongst stakeholders. Other considerations may include training, schedule, procurement, staff, risks, safety, and impacts to farming operations. Sorting projects by ESR should help identify the complexity of the implementation step with redesign projects likely being the most complicated.

Implementation of the methods to measure indicators may involve the installation of equipment (e.g. monitor energy usage over the short or long term). As previously mentioned, reflecting on results and the changes made may not typically be done on NS farms. However, this step can prevent future problems and help inform future decisions through consideration of the following:

- Were the targets achieved?
- Were the targets appropriate? Is more or different work required to meet the target?
- Are there further improvements to be made?
- Are there learnings that can be applied to future projects?
- Are there next steps or is future work needed? If so, return to step 1.

Here is a summary of the implementation process:

1) Implement the change.

   a) Manage the energy upgrade implementation (project management, resource identification, other considerations).
2) Implement the measurement methods.
   a) Collect data.
   b) Review results.
   c) Determine if targets have been met.
3) Reflect on changes made.
   a) Reflect on learnings.
   b) Determine next steps.

5.5.2 Case studies

Case studies were used to apply FESA retrospectively on two large energy projects (redesign and substitution). The case studies are on a dairy farm and a poultry operation which together represent the highest energy users by farm type in NS (Bailey, Gordon *et al.,* 2008). The case studies test the validity of FESA, and its application in practice, and provide a holistic view (Noor, 2008).

5.5.2.1 Case study – Windmill Holsteins

Windmill Holsteins is a dairy operation located in Colchester County. The farm milks 105 cows (250 head total) and produces 1 million L of milk per year. In 2014, the farm began operation of an on-farm, anaerobic digester (AD) producing biogas for production of up to 500 kW of electricity. It is currently the only on-farm digester system in NS and the farm is currently participating in the NS Community Feed-In Tariff (COMFIT) program. The COMFIT program provides a contract for the purchase of electricity for combined heat and power (CHP) biomass (including AD) at a rate of 17.5¢ per kWh (Nova Scotia Department of Energy, 2011a).

The farm had been using an outdoor wood-fired boiler for hot water for the dairy. Prior to that, it used an oil-fired system, but it was too costly. However, burning 181 m^3 of wood per year takes inordinate time and effort. Additionally, the farm was having issues with variability in the hot water adversely affecting milk quality. It needed a reliable source of consistently hot water. The farmer needed to change the system.

Additionally, Windmill Holsteins is a family operation and creating jobs for family members to stay on the farm was a priority for the farm. One way to do this is to increase farm size (e.g. buying milk quota) but quota is not always available. This led the farmer to research other possibilities. Another option that the farm examined was an AD. It can generate revenue, support the farm with a better nutrient source (liquid digestate), improve environmental sustainability, improve neighbour relations (decreased odour), provide a source for bedding (digester solids vs shavings), provide heat/hot water, and create on-farm employment. The original idea came from a family member's trip to India where a small AD unit was observed; this led to research of popular European systems.

The farm was approached by a consultant to install wind turbines at the farm site but instead the farm used the consultant as a project manager to investigate an AD further. This involved a trip to Ontario and information gathering. The system was sized based on feedstock availability (on-farm waste, off-farm waste, and forages) and access to capital. The price per kWh was fixed as it was a COMFIT project. It took approximately four years to bring the project from concept to reality. The project itself was complicated involving community meetings, grid-connection cost surprises, permit complications, and years of expenditures with no income generated. Additionally, the original plan was to have the company that did the capital work also do the maintenance work as needed. However, this company is in Germany and maintenance costs quickly became expensive due to transportation and exchange rates. There was a lack of local expertise, but the farm has been hiring contractors locally to try to build local skill capacity. Overall, the project has resulted in huge improvements to the farm. There are decreased costs for shavings/bedding, chemical fertilizer purchases are no longer required, heat issues have been resolved, there is no odour associated with digestate spreading, and revenue has been generated from tipping fees for off-farm waste to be used in power generation.

Although a process with discrete steps to follow for an AD project was highlighted by the farmer as "nice to have" to help improve the decision-making process, being the first one to do a project of this type in NS has resulted in access to innovation funding (i.e., NSDA

Energy Pilot Program). The payback for this project is estimated at 12 years with a 20-year project life with $2+ million investment. However, the project is not primarily about economics. Clearly, social goals like creating employment for family members were paramount. When asked if the farmer would do it again the answer was yes, "it's all about the long term".

Additional ongoing energy projects include lighting replacement. This involves design for the appropriate light level for the dairy operation. Improved light levels can increase milk production (Dahl, Buchanan and Tucker, 2000) and improve safety. Efficient lighting systems can save electricity. Although lighting upgrades had been identified in a past energy review as an energy upgrade to pursue, the AD project had been a huge focus and other projects are only now being considered. Lighting, for example, is being worked on over time with areas with insufficient lighting targeted first. The farmer ultimately wants to decrease electricity use on the farm but currently has no target. An energy audit should be able to provide the necessary information to develop a target. The farmer did discover, by chance when the power went out in other areas of their operation, that the barn cleaner uses large amounts of energy and the farmer now tries to reduce its use when possible (there is currently no goal or plan for this). The farmer is also considering adding a greenhouse that would run off the AD waste heat to generate revenue and create farm family job(s) as part of a retirement plan.

FESA has been applied retrospectively to the above case study (Table 5.3). The steps of FESA are listed below with instructions for, and comments on, each step. The instructions are taken directly from the approach/methods for each step.

Table 5.3 Retrospective FESA Application on Windmill Holsteins Case Study

<table>
<tr><th colspan="3">Step 1. Determine Values, Objectives, Indicators, and Targets</th></tr>
<tr><th>Step</th><th>Instructions</th><th>Comments</th></tr>
<tr><td>1.1</td><td>Identify Values

Identify the reasons for an energy upgrade to be considered. What does the farmer value with respect to energy? Consider stakeholders.</td><td>Reason(s): necessity (lack of hot water negatively affecting milk quality)
Values: 1) quality product (milk), 2) family, 3) community, 4) farm longevity
Stakeholders: Family, neighbours, and consumers of milk were all considered.

The COMFIT process required community/public and Aboriginal engagement [154]. Therefore, more rigorous stakeholder input was sought during Step 3 (implementation) of the AD project.</td></tr>
<tr><td>1.2</td><td>Determine objectives

Make a broad statement that describes the desired future state or condition for each value.</td><td rowspan="3">1 Value - Quality product
a) Objective - improve milk quality (reduce milk quality incidents)
Indicator - Milk quality was identified to be of value (and the main reason for the AD project); however, the farmer did not determine an indicator for this value. The number of milk quality incidents from lack of hot water could have been utilized as an indicator if the source of the incidents could be identified. Otherwise, if water temperature was monitored, this could be used as an indicator.
Target – No milk quality incidents associated with hot water after implementation of the AD unit.
2 Value - Family
a) Objective - create opportunities/jobs for family on farm
Indicator - # of jobs created (for family members)
Target - create at least one extra job for family on farm (baseline is number of on-farm family jobs pre-project)
3 Value – Community
a) Objective - improve neighbour relations (reduce odour)
Indicator - The farmer did not determine this indicator; however, the number of neighbour complaints could have been used
4 Value – Farm longevity
a) Objective – decrease operating expenses
Indicator - chemical fertilizer purchases
Target - no purchased chemical fertilizer
b) Objective - maximize revenue
Indicator – kWh of power generated
Target - operate AD at capacity (running at 500 kW capacity). However, it is not realistic to run at capacity all</td></tr>
<tr><td>1.3</td><td>Determine indicators

Determine an Indicator for each objective that is measurable and representative of the corresponding value.</td></tr>
<tr><td>1.4</td><td>Establish targets

Describe the desired future condition of each indicator.</td></tr>
</table>

Step 1. Determine Values, Objectives, Indicators, and Targets		
Step	**Instructions**	**Comments**
		the time. The target in this case could be adjusted for a maintenance factor, like running at nameplate 80% of the time. This could be adjusted over time to work towards nameplate capacity.

Step 2. Develop Strategy for Achieving Targets		
Step	**Instructions**	**Comments**
2.1	Determine energy improvement options that best meet targets *Complete an energy audit* *a) Sort options by major farm level activity.* *b) Sort options using ESR.* *c) Consider alternatives.*	The FES conducted an energy review on the farm in 2012, with recommendations for a lighting review via Efficiency NS programming as the farm had a mixture of lights including T12s, T8s, and metal halides. The farm already had a plate cooler but no heat reclaimer as, at the time, water was heated with wood. The farm had followed up on the energy review and Efficiency NS had completed a report on lighting upgrades, but they did not proceed with the implementation. The farm is interested in LED lighting and is waiting for price point to drop. A more detailed energy audit may identify further options. For example, the identification of the barn cleaners as heavy energy users and the option to reduce use, was identified by the farmer, by chance, due to a power outage. • Waste handling (barn cleaners) had been identified by the farmer as an energy use that could be reduced (Efficiency). Energy conservation was not an identified value initially. • Lighting had been identified as an area of improvement for energy savings (Substitution). Energy conservation was not an identified value initially. • Water heating had been identified by the farmer as a problem area due to milk quality issues. AD was not identified in the energy review but was an option being considered (Redesign). This option links to the targets identified by the farmer. One could argue that the AD could fit under substitution, but it is such a large project that fundamentally changes the nature of the farming operation that it has been placed under redesign. Wind power was considered as an alternative to AD but did not address the identified goals. Lighting alternatives include HPT8 and LED lighting. LED lighting is of interest to the farmer.
2.2	Set Timeline *Utilize ESR for short, medium and long-term planning.*	Determination of each change(s) to implement now and later: • Efficiency: reduce barn cleaner usage (run once per day vs twice) was done in a short timeframe. • Substitution: Lighting can be done later as it does not address current goals. However, if insufficient light levels necessitate lighting replacement, these areas can be completed in the

Step 2. Develop Strategy for Achieving Targets		
Step	**Instructions**	**Comments**
		short term and the goals and timeline can be revised. Also, the technology option price point may drop if the project is done later. • Redesign: The AD project took over 4 years from concept to commission. The project itself was initiated quickly to take advantage of the COMFIT program. Many parts of the project were identified for short-, medium-, and long-term planning (Step 3.1 below). A greenhouse project is being considered to use the waste heat. It may be the next large project (long-term).
2.3	Determine how to measure indicators. *Identify if monitoring equipment is required. Develop a process/protocol for data gathering (as needed).*	Process for measuring each indicator: 1 a) Although the number of milk quality incidents from lack of hot water was not tracked, a system to record these incidents could have been implemented. 2 a) The number of jobs created (for family members) on farm can be measured through observation. 3 a) Although the farmer did not track the number of neighbour complaints, a system to record odour incidents could have been implemented. 4 a) The amount of purchased fertilizer can be determined from expense data. b) The AD unit itself is designed to provide data on power generation (kWh generated).

Step 3. Implement		
Step	**Instructions**	**Comments**
3.1	Implement the change *Manage the energy upgrade implementation (Project management, resource identification, other considerations)*	An AD is a large project with multiple complicated steps to get to completion. A project manager was used. Resources: • feedstock (on-farm waste, off-farm waste and forages) • capital (financing), funding applications (COMFIT, Energy Pilot) • time (it took approximately 4 years) • people (the project manager was used to manage contractors, vendors, and funding applications; also, community meetings were conducted for stakeholder consultation) Other considerations: • training (need to build local expertise for maintenance) • schedule (long-term project) • procurement (international supplier, exchange rates, shipping and availability issues) • staff • risks (grid connection, permit complications) • safety • impacts to farming operations (upfront expenses without income generated)

Step 3. Implement		
Step	**Instructions**	**Comments**
3.2	Implement measurement methods *Collect data, review results, and determine if targets have been met.*	Many of the project targets have been met: 1 a) Although milk quality incidents were not formally being tracked, the farmer is aware of no milk quality incidents associated with hot water since the AD system has been operational. 2 a) This project has created a job for the running of the AD unit itself; as well, excess heat could create future jobs. The farm is considering adding a greenhouse to the operation to utilize the excess heat and create additional jobs and revenue. 3 a) Although this is not formally being tracked, there is no odour associated with the spreading of liquid digestate compared to previously used liquid manure and the farmer is aware of no odour complaints since the AD unit has been operational. 4 a) Chemical fertilizer use was not tracked, but expense data could be used as it is available in the farmer's accounting information. The farmer does know that chemical fertilizer is no longer a farm expense. b) The AD system itself is designed to provide feedback on performance and data on kwh generated. The AD unit is not consistently running at capacity. Maintenance (finding skilled local labour) has been challenging and can influence downtime.
3.3	Reflect on changes made. *Reflect on learnings and determine next steps.*	The AD project has met expectations and although it is not running at capacity, it is providing on-farm job(s) and other benefits. For example, the original heat problems with inadequate hot water and resulting impacts on milk quality have been resolved; the farm now has excess heat. There is also no odour associated with spreading digestate, compared to manure, and this has created flexibility on when it can be spread on fields and eliminated odour complaints. Novel, innovative projects can have certain opportunities and challenges, for example: • Local expertise is important for ongoing maintenance and may not exist initially; this can be developed in time. • Grid connection and permitting can be complicated, expensive and result in delays. • There may be funding opportunities. Next steps: lighting, potential for greenhouse with excess heat, retirement. The farmer could benefit from having an energy audit done

Step 3. Implement		
Step	**Instructions**	**Comments**
		before the next project. This may result in further identification of energy projects for consideration. Goals should be revisited and revised.

5.5.2.2 Case study – Brookside and Round Hill Poultry

Brookside and Round Hill Poultry are two poultry (broiler) operations located adjacent to each other in Annapolis County. The farms produce over 500,000 chickens per year. In 2011, the farms installed a Ground Source Heat Pump (GSHP) system in two large broiler barns to provide heat. They were the first ones in Eastern Canada to do this.

The farms had been using an outdoor wood boiler for hot water for the in-floor barn heating system. They also had the ability to heat with an oil-fired system. Oil costs were too high and unpredictable, and the wood system used 544 m^3 per year and was a large strain on time. The wood system was at the end of its life and there were environmental and social impacts associated with burning 544 m^3 of wood:

- Impacts to the environment and neighbours, complaints from particulate matter from inefficient burning;
- The effort required (labour, time, and money) due to quantity of wood consumed (loading boiler 3-4 times per day);
- Safety issues with running power saws and lifting heavy wood;
- Age of farmer and work force;
- Practicality.

Oil heating was an option, but the farmers wanted to cut costs. Wood heating was cheaper to operate than oil but was no longer an option for the reasons listed above. The motivation for considering GSHP over other options was more about economics than innovation. However, being the first to implement meant access to innovation funding from the provincial government that helped make the project attractive financially. The project would not have been done without access to funding. In total, the farmers received close to 50% funding from the following sources (Farm Energy Nova Scotia, 2012b):

- Energy Pilot Program, NSDA
- EcoEnergy Retrofit Program, Government of Canada
- Business Energy Rebates, Efficiency NS
- Farm Investment Fund, NSDA

The farmers considered solar water and electric hot water from wind or PV but found wind reliability to be low and PV to be inefficient, and they lost interest in solar water.

A site visit was made to an Ontario farm that had put in a GSHP system on its poultry operation. The tour helped understand the benefits, costs, and payback. The farmers were impressed by the technology and the decision was made to pursue this heating option with hopes to cut heating costs in half compared to oil. The goal was to be more competitive in NS (by comparing cost of production to other farms). The Chicken Farmers of NS gives out information on industry average cost of production but does not release data on farm rank. Although the farmers' goal was to have the best cost of production, it is only possible to determine if the farm is better than average.

The system was sized based on hot water needs, with three 6-tonne units installed for each farm to allow for staging. Information and services were sought from a consultant, engineer, manufacturer, and installer as well as a plumber/heating technician. The project took four months to complete and is expected to provide a five to seven-year return on investment on a $230,000 project (total project costs before funding). As mentioned above, the farmers did receive some innovation funding as they were the first poultry farms in NS to implement this technology.

The project has made a huge difference in labour, morale, neighbour complaints, cost savings, and competitiveness. The improvement has been measured by researchers at Dalhousie University which conducted a monitoring study on the project to validate performance (Farm Energy Nova Scotia, 2012b). Data are available on cost of production (benchmark) and oil usage/cost per kg of production to compare to past years with the target of cutting energy costs/kg in half. In 2015, oil prices dropped so the cost/kg benefit is less than expected, but the project is still cost-effective. Since the farms have kept the existing oil system as a back-up, they could use oil in the future if oil prices continue to drop. However, the decrease in operating costs associated with the GSHP has allowed the farms to hire more employees and provided flexibility in lifestyle (semi-retirement). Thoughts about retirement influence decisions as well. For example, at this point in his career, one of the farmers will only consider projects with quick paybacks (less than five years).

The farms have implemented other energy upgrades and have additional projects in the works. They have replaced older circulation pumps and are currently replacing barn lighting. Although lighting upgrades had been identified in a past energy review as an energy upgrade to pursue, the project was postponed awaiting advances in LED technology. Although energy saving was a motivator, the drive to change the lights was due to multiple factors including advice from an electrician to wait on the technology. The farms have T8 and T12 lights. T12 lights are now obsolete and parts are expensive and hard to find so that has been the motivator for recent upgrades for those lights. LED technology has advanced for poultry operations and the price has dropped. LEDs are reliable, available, efficient, and dimmable. LEDs are also appropriate for poultry; these lights can fit into existing fixtures and are cheaper than in the past. The plan is to have all lights changed to be the same technology. For this upgrade, the farmers are not motivated by funding programs and have been changing lights without applying to programs. So, for smaller projects like the lighting, funding was not important, but it was very important for the large GSHP project.

FESA has been applied retrospectively to the above case study (Table 5.4). The steps of FESA are listed below with instructions for, and comments on, each step. The instructions are taken directly from the approach/methods for each step.

Table 5.4 Retrospective FESA Application on Brookside and Round Hill Poultry Case Study

Step 1. Determine Values, Objectives, Indicators, and Targets		
Step	**Instructions**	**Comments**
1.1	Identify Values *Identify the reasons for an energy upgrade to be considered. What does the farmer value with respect to energy? Consider stakeholders.*	Reason(s): operating costs (the wood burning system was at the end of its life and relying on the oil system alone was costly) Values: 1) farm ranking (cost of production); 2) lifestyle flexibility; 3) community; and 4) safety Stakeholders: family, neighbours, staff, consumers of poultry products
1.2	Determine objectives *Make a broad statement that describes the desired future state or condition for each value.*	1 Value – Farm ranking a) Objective - be more competitive Indicator - cost of production (operating costs per kg). Rather than cost of production, energy (heating) expenses per kg of chicken could be used as an indicator and could be helpful to determine if the project is influencing the cost of production. Cost of production is influenced by more than energy usage and therefore may not, on its own, be a useful indicator. Costs can be calculated annually or more frequently. Target – The baseline is industry average cost of production for the previous year. The target is to be lower than this value with the post-GSHP on-farm cost of production. The pre-GSHP cost of production should also be used as a baseline with a target for being lower. b) Objective - lower heating costs Indicator – energy costs per kg Target - actual costs (current energy cost/kg) being half of the potential value (current price of oil x past oil usage per kg) 2 Value – Lifestyle a) Objective - create lifestyle flexibility for farmers Indicator - number of employees. The farmers did not actually gather data on any indicator of lifestyle flexibility. Rather, the farmers are determining this subjectively (e.g. opportunity for vacation). An increase in employees (or increase in hired labour hours), without increasing cost of production, could be used to indicate an improvement in time flexibility for the farmers but it could be problematic as many factors influence cost of
1.3	Determine indicators *Determine an Indicator for each objective that is measurable and representative of the corresponding value.*	
1.4	Establish targets *Describe the desired future condition of each indicator.*	

Step 1. Determine Values, Objectives, Indicators, and Targets		
Step	**Instructions**	**Comments**
		production. Using a ratio of farmers' work hours to non-work hours may be a better indicator of lifestyle flexibility for the farmers but this type of information would need to be tracked. Target - Number of employees pre-GSHP with a target to hire one additional employee (without increasing cost of production compared to pre-GSHP). 3 Value – Community a) Objective - improve neighbour relations (reduce neighbour complaints associated with particulate matter) Indicator - the farmers did not determine this indicator. The number of neighbour complaints (associated with air quality) could have been used. However, the number of past neighbour complaints (associated with air emissions) had not been previously quantified, so results would be anecdotal. Target - The target is to have no complaints regarding air emissions post-GSHP. 4 Value – Safety a) Objective – improve safety Indicator – The farmers did not determine this indicator; however, safety incidents associated with heavy lifting could be considered. Target - No safety incidents associated with heavy lifting.

Step 2. Develop Strategy for Achieving Targets		
Step	**Instructions**	**Comments**
2.1	Determine energy improvement options that best meet targets *Complete an energy audit* *d) Sort options by major farm level activity.* *e) Sort options using ESR.* *f) Consider alternatives.*	The FES had completed an energy assessment on the farm in 2010; however, the one of the farmers was not able to recall any details, just that the review had been done. The FES would have made recommendations for a lighting review via Conserve NS/Efficiency NS programming, as the farm had T12 lighting. The farmers are interested in LED lighting and are waiting for the price point to drop. A more-detailed energy audit may identify further options. • Water heating: GSHP (substitution), circulation pumps (substitution) • Lighting had been identified as an area of improvement for energy savings (substitution). Solar water and electric hot water from wind or photovoltaics (PV) were considered but concerns over wind reliability and PV efficiency resulted in lost interest in these alternatives for water heating. Efficient wood burning was excluded as it did not meet goal 2. Lighting alternatives include HPT8 and LED lighting. LED lighting is of interest to the farmers.

Step 2. Develop Strategy for Achieving Targets		
Step	**Instructions**	**Comments**
2.2	Set Timeline *Utilize ESR for short, medium and long-term planning.*	The GSHP project took four months to complete. Timing was important as part of the planning of the project since the installation of underground piping could not be done in frozen ground. Grant availability at the time influenced scheduling of the GSHP project as well. The project would have been put on hold without the availability of grants. Circulation pumps were replaced with newer models after the GSHP project. Lighting replacement is ongoing and being done in stages rather than one project. The lighting project was on hold pending reliable technology availability and is currently underway. The farmers want to have the same technology for all interior barn lighting (improve reliability, parts availability, efficiency).
2.3	Determine how to measure improvements. *Identify if monitoring equipment is required. Develop a process/protocol for data gathering (as needed).*	Process for measuring each indicator: 1 a) The Chicken Farmers of NS has information on industry average cost of production. Cost of production (benchmark) data and oil and electricity usage/cost per kg of production information are available through on-farm accounting which enables the comparison to past years. Cost of production can be compared to past years and to industry average. 1 b) Electricity use for the GSHP for both barns can be measured together but they are not metered independently. Researchers at Dalhousie University conducted a monitoring study for the project which included the installation of monitoring equipment to validate the project performance with respect to energy usage. 2 a) The number of employees (or total hours of hired labour) would be available from accounting records. 3 a) Neighbour complaints were not tracked, but a process to document complaints could have been implemented. 4 a) Safety incidents were not tracked, but a process to document incidents could have been implemented.

Step 3. Implement		
Step	**Instructions**	**Comments**
3.1	Implement the change *Manage the energy upgrade implementation (Project management, resource identification, other considerations)*	The GSHP project was a large project and not previously done on a NS poultry operation. Information and services were sought from a consultant, engineer, government staff, manufacturer, and installer as well as a plumber/heating technician. Resources: • capital (financing), funding applications • time and timing (it took approximately four months) with ground work done in warmer seasons • people Other considerations: • training (need to build local expertise for maintenance of GSHP) • schedule

<table>
<tr><th colspan="3">Step 3. Implement</th></tr>
<tr><th>Step</th><th>Instructions</th><th>Comments</th></tr>
<tr><td></td><td></td><td>• procurement
• staff
• risks
• safety
• impacts to farming operations</td></tr>
<tr><td>3.2</td><td>Implement measurement methods

Collect data, review results, and determine if targets have been met.</td><td>This project was evaluated by researchers at Dalhousie University which allowed for feedback on performance. Other targets such as hiring another employee and no neighbour complaints are also straight-forward.

The farmers use various sources of data to verify if targets have been met and to monitor progress. Most data are gathered through regular accounting (energy bills, production data).
Many of the targets have been met:
1 a) The farms have a better than average cost of production.
1 b) The price of oil dropped in 2015 which impacted the results for current energy costs/kg vs potential energy costs/kg. This result is not being met but the project is still feasible.
2 a) The farmers have hired an additional employee and the farmers now have more flexibility.
3 a) There have been no neighbour complaints regarding air emission since project implementation.
4 a) N/A</td></tr>
<tr><td>3.3</td><td>Reflect on changes made.

Reflect on learnings and determine next steps.</td><td>The GSHP project has met expectations and although the price of oil has dropped, thus decreasing the financial benefit of moving away from oil fired heat, it is providing the farmers with lifestyle flexibility and other multiple benefits. Implementing a novel, innovative project allowed access to funding opportunities.

Next steps: lighting (replace T8 and T12 lights with LED)

The farmers could benefit from having an energy audit done before the next project. This may result in further identification of energy projects for consideration. Objectives should be revisited and revised.</td></tr>
</table>

5.5.3 Reflections on the Framework

It became apparent during the case-study tests of FESA that certain aspects may be challenging to implement, and some changes would be warranted. Examples of structural changes to FESA include:

- Changing from a linear approach to planning to a concurrent model (Step 1 and Step 2).
- Modifying the order of steps for planning.

- Combining Do, Check, Act from three separate steps into one implementation Step (3).

A major modification to process was with Step 1. Setting goals was the original Step 1; that was changed to setting VOITs. This was necessary to emphasize the importance of determining values, not skipping to goals, and providing a solid basis for understanding that values are not goals. Utilizing the VOIT framework as a guide for Step 1 provides needed clarity, especially since one of the most challenging steps when using the framework is identifying values. This may be a barrier to practical application of FESA. Values guide decision-making and our values should be reflected in the priorities we choose. Values are often thought of as being personal but there are different levels of values, for example: personal, groups (teams), organizational (sectoral) and societal (Charlesworth, 2018). The definition of ES reflects societal values, and the interview and survey results provide insight into farmers' reasoning for energy decisions and provide examples of organizational values. The case studies highlighted personal and group values that did not show up in the interviews and surveys. This demonstrates the importance of allowing farmers to include their personal and group values so that decisions remain relevant to them. Further research should build upon the list of values identified in this research (Table 5.5) and sort them into themes for application.

Table 5.5 Levels of values associated with ES in Canada and on NS Farms

Value Level	Source	Values Identified
Personal (farmer) and Group (farm staff)	Case Studies	quality product, family, community, farm longevity farm ranking (cost of production), lifestyle flexibility, competitiveness
Organizational (NS Agricultural Sector)	Interviews and Surveys	energy conservation, energy efficiency, self-sufficiency, innovation, animal welfare, cost efficiency, cost stability, cost predictability, capital cost efficient production, local business development, biodiversity, air quality, water quality, waste reduction, climate change mitigation, natural resource conservation, safety, time efficiency, convenience
Societal (Canada)	Energy Sustainability Definition*	energy affordability, energy source availability, energy source reliability, energy source efficiency (production and distribution), energy efficiency

Value Level	Source	Values Identified
		(use), air quality, water quality, waste diversion, human health, natural resource protection/conservation, biodiversity, soil health, farm nutrient efficiency, erosion mitigation, water quality, climate change mitigation, wildlife habitat, energy conservation, energy efficiency
Potential gaps		climate change adaptation, stakeholder involvement, resilience

*As defined in the Introduction section with additional values derived from environmental sustainability indicators for Canada and Canadian Agriculture (Canadian International Development Agency, 2002; McRae, Smith and Gregorich, 2000; Environment Canada, 2017)

Another challenging step with FESA is 'reflect on changes made'. Reflection is the last step of FESA and although not inherently challenging to do, it may not be implemented. A recent study found that reflecting on work improves job performance (Di Stefano *et al.,* 2016). In fact, the study showed a greater than 20% increase in work performance with devoting merely 15 minutes of the day to reflecting on lessons learned that day rather than taking that time to do additional work (Di Stefano *et al.,* 2016). So although reflection may be beneficial, there may be a bias towards action, a lack of knowledge as to how to reflect, a resistance to changing how to think, a fear or dislike of finding negative results, and even a difficulty in seeing how it will pay off compared to moving onto the next project (Porter, 2017). Reflection is also not a typical step in implementing energy upgrades on NS farms; there is usually little to no follow-up with energy professionals.

FESA could be implemented by through existing environmental extension or energy audit programs. Indicator development can draw from the strengths of these programs, for example: economic indicators from energy audits; environmental indicators from environmental extension. There is also an opportunity to improve the monitoring and evaluation of program effectiveness through measurement and refection. A self-assessment type workbook could also be developed for farmers to implement FESA, but significant work would need to be done to develop this tool.

Further research should test FESA on farms interested in pursuing future energy-related projects (proactive vs retroactive). This will help highlight any additional changes needed. FESA seems to work well for larger projects; farmers may not wish to use FESA if their only interest is in a small efficiency upgrade. However, FESA is likely beneficial in NS as many farms have implemented EE and EC upgrades, but not as many have implemented RE upgrades (Bailey *et al.,* 2018). There are opportunities for substitution and redesign projects. There are also opportunities beyond NS. NS represents less than 2% of all the farms in Canada (Statistics Canada, 2017). FESA could also be applied across North America and beyond.

Although the framework requires further testing, it has been built from elements of other robust frameworks related to the pursuit of sustainability. This strong foundation is the main strength of this framework.

5.6 CONCLUSION

FESA was developed to help in the decision-making process to improve farm energy management. It provides a series of steps that can be followed by farmers and energy professionals providing support services for energy-related projects on the farm. While developed for NS farmers, it could be applied to farms elsewhere in Canada or abroad.

FESA allows for the consideration of environmental and social priorities, not just economics, when exploring energy upgrades. Incorporating sustainability pillars into the process does not need to be complicated and can add value and relevance to projects. The framework helps quantify the multiple benefits of projects. This is especially important since energy reviews tend to focus on economic criteria, but social criteria seem to play an important role, especially for RE projects as seen in the case studies and survey results.

FESA builds upon and increases the relevance of energy audits. While many farmers have had support (e.g. energy audits), energy upgrade opportunities remain. Also, as technology changes, new opportunities arise (e.g. LED lighting). This was apparent in both case studies. The framework increases the relevance of energy audits over the long term so that an energy audit report is not forgotten on the shelf. It allows for setting a timeline to trigger action/implementation for multiple projects. Using the framework will help keep the energy audits relevant, part of an enduring plan, and incorporate continuous improvement rather than one-off projects.

FESA allows for the systematic consideration of all important elements of energy decision-making. It includes three main steps made up of a total of ten sub-steps. In the past, the focus of energy upgrade programming was often based on only one sub-step: to determine energy improvement options. Sometimes a second sub-step was included: implement the change. However, without follow-up, it is difficult to know if there have been energy reductions, if program goals have been met, or if there are any lessons learned. It can build accountability into the process and relevance for multiple stakeholders.

FESA uses a management system approach to integrate continual improvement over time. It provides the context for setting performance indicators and measuring meaningful results. The case studies show that results are often anecdotal. The framework sets a process in place to measure actual results and reflect on them to effect improvement and change. Farmers are not the only ones who could be informed by measuring results. EE/EC and RE support programs could measure program success not by the number of reviews completed, but by measurable results (energy reductions, reduced GHG emissions). The framework can be adapted to be used by farm energy consultants, program administrators, and farmers themselves.

A critical next step for framework development is FESA's application on farms interested in pursuing future energy-related projects (proactive vs retroactive). Farmers are making energy improvements over time and are interested in future implementation of energy upgrades. Rather than an energy audit report that sits on a shelf, using this framework can help with long-term planning and continual improvement. There is great potential to save money and energy, as well as see society and environmental benefits on a large scale.

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CHAPTER 6 CONCLUSION

Encouraging EE, EC and RE implementation in an effort to be more sustainable has been a policy and program focus for the past decade in many countries around the world, especially in Canada and the province of NS. Program efforts have involved providing support for making energy decisions, but measurable outcomes associated with EE, EC and RE programs are lacking. Do we know if energy has been saved? What technologies have been implemented? Is there an opportunity for additional implementation? Is sustainability considered when exploring energy options?

This research has shown that there have been tremendous energy reductions on NS farms through EE, EC, and RE implementation; a success story that should be celebrated. However, there continue to be plenty of opportunities for NS farmers to increase implementation of EE, EC, and RE options. Programming has included resource support of money and expertise: government funding, dedicated government staff support specific to the agricultural industry, dedicated academic research specific to the agricultural industry, the creation of an energy conservation and efficiency agency, and incentives targeted at agricultural technologies. Programs have relied on EE, EC, and RE implementation to help move towards sustainability. However, the values inherent in sustainability itself are not often used to guide these energy decisions. This research has identified an initial set of values that can be used to guide priorities and decision-making. Further research should build upon this multi-level list of values and sort them into themes for application both within Canada and beyond, including other sectors.

Utilizing values derived from ES in decision-making is a fundamental change in the support process. The research has identified that the energy-related decision process of NS farmers is mostly centred on economics, and social and environmental elements are only considered, if at all, when comparing alternatives. This is true for RE upgrades as well, but social aspects are a secondary factor in implementing a RE upgrade. The focus on monetary drivers may be directly linked to the current type of support offered. Although it is extremely positive that NS farmers who received support were more likely to implement EE, EC, and RE, current support processes (e.g. energy audits) tend to rely exclusively on cost-benefit analysis.

Thus, while support processes have been effective at promoting implementation of EE, EC, and RE, they have yet to promote sustainability when considering energy options. This leads to the main goal of this research: to develop and test a framework that incorporates sustainability considerations into NS farm decision-making when selecting EE, EC, and RE options to improve farm energy management. The framework for energy sustainability in agriculture (FESA) has been developed to support the consideration of environmental and social priorities, not just economics, when exploring energy upgrades and helps quantify the multiple benefits of projects. FESA provides a series of steps that can be followed by farmers and energy professionals providing support services for energy-related projects on the farm. The framework has been built from elements of other robust frameworks related to the pursuit of sustainability. This strong foundation is the main strength of the framework.

The past energy policies and programs, and the many people who have made energy upgrades who are examples for others, may help carry the momentum forward and result in more implementation and future energy savings. FESA builds upon the implementation success of past programs. Many programs have focused on electricity reductions and efficiency and substitution projects (e.g. lighting, insulation). These programs have likely captured more than half of potential adopters among NS farmers but RE implementation is still in its early stages. However, as technology changes, new opportunities arise (e.g. LED lighting). There are still many opportunities for more ESR projects but especially for larger substitution (i.e. RE) and redesign type projects. Those considering energy upgrades may not wish to use FESA if their only interest is in a small efficiency upgrade. FESA is more applicable to larger projects. In addition, many energy audits have been completed. One of the advantages of FESA is that it can help keep energy audits relevant, as part of a plan over time, and incorporate continuous improvement rather than one-off projects.

FESA addresses gaps in existing energy support processes such as monitoring and evaluation. When monitoring and evaluation have been in place, the focus has been on economic indicators and other indicators that represent weak opportunities to make meaningful assessments of results (e.g. the number of energy audits completed does not permit an assessment of actual energy savings). FESA demands the setting of performance indicators, the meaningful measurement of results, and incisive reflection to effect improvement and change. FESA uses a management system approach to foster continual improvement and includes the systematic consideration of all important elements of energy decision-making.

Although FESA has been designed with NS farmers in mind, its applicability clearly extends beyond this small population of agricultural producers. Further research should test FESA on farms elsewhere, beginning first in other Canadian provinces. The framework should also be tested in other sectors. This will help determine its practicality and improvements that may be warranted. There is great potential to save money and energy, as well as see society and environmental benefits on a large scale.

If sustainability remains a core value for policy-makers, it is time for reflection on what that really means to those they serve. There are many different definitions and perceptions of sustainability. Instead of promoting options that potentially may be more sustainable, it may be time to use the values inherent in sustainability itself to guide decisions; and build accountability into that process.

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APPENDIX A INTERVIEW GUIDES

Interview Guide for Energy Professionals

Background Questionnaire

1. Approximate # of farms audited______________________________________
2. Years of experience in energy management______________________________
3. Business location (Province/State)_____________________________________

Opening Question

1. What is your name and the name of your business?

Introduction Question

2. Tell me about the type of work that you do.

Transition Question

3. What are the reasons why businesses, specifically farms, make energy changes? *(examples of energy changes can include energy conservation, energy efficiency, renewable energy, fuel switching)*

Key Question

4. How do you help these businesses make their decision?
   What information do you provide?
   In your opinion, what are the most important criteria for choosing one energy option over another [e.g. economics (cost savings), environment (water use), social (time)]?
   What other criteria are considered?
   Can you think of ways to help improve the decision-making process?
   Are you aware of any programs to help these businesses with their energy choices?
   Do you do any follow-up with these businesses to see if they have implemented energy changes?

Ending Question

5. Can you highlight the main reason why you would recommend one energy option over another? *What has the greatest influence (e.g. any programs, funding)? What problems have you encountered?*

Concluding Question

6. Is there anything else that you would like to add that we haven't covered?

Interview Guide for Farmers

Background Questionnaire

1. Gender Male/Female
2. Age range 18-25 26-35 36-45 46-55 55+
3. Primary Farm Type ____
4. Secondary Farm Type____
5. Farm Size (Gross Farm receipts) range_______________________________
6. Farm location (county)__________________________________

Opening Question

1. What is your name and the name of your business?

Introduction Question

2. Tell me about a recent energy improvement you have made on your farm? (*start with one but allow for more than one)*

Transition Question

3. What were your reasons for considering energy changes to your operation?
   What were the most important reasons for you to make a change? (e.g. cost savings)
   Was the environment one of your considerations? (e.g. water, land, air, GHG issues)
   What about social or political considerations such as safety or labor/time requirements?

Key Question

4. How have you gone about making your decision?
   What information did you gather to make your decision?
   Where did you go to get information?
   What programs have you used?
   Can you think of ways to improve the decision-making process?

Ending Question

5. Can you highlight the main reason why you would pick one option over another?
   What has influenced you the most (e.g. any programs, funding, peers)?
   What problems/obstacles have you encountered? (e.g. mixed messages, time frame, financing, funding, contractor availability, labor, etc…)

Concluding Question

6. Is there anything else that you would like to add that we haven't covered?

APPENDIX B SURVEY QUESTIONS

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DALHOUSIE UNIVERSITY
Inspiring Minds

Incorporating Sustainable Energy Decisions in Agriculture

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Please contact Julie Bailey for additional information or questions.

I invite you to take part in a research study being conducted by me, Julie Bailey, a graduate student at Dalhousie University, as part of my PhD. I am also the Farm Energy Specialist with the Nova Scotia Department of Agriculture. Your participation in this study is voluntary and you may withdraw from the study at any time. The study is described below. This description tells you about the risks, inconvenience, or discomfort which you might experience. Participating in the study might not benefit you, but I expect to learn things that will benefit others. I am the principal investigator and you should discuss any questions you have about this study with me.

The purpose of the study is to develop and test a framework (a tool) to incorporate energy sustainability into NS farm decision-making when selecting energy conservation and generation options. The overall research will involve three phases: 1) interviews, 2) surveys, and 3) on-farm case studies. You are being asked to participate in Phase 2. The results of this study will be included in my PhD thesis and in publications and presentations.

You may participate in this study if you are a registered NS farmer. In April 2012, this survey was sent to all registered farmers in NS in the April mail-out of the NS Federation of Agriculture newsletter. **Due to a low response rate, the survey is being resent.** If you completed and returned this survey earlier this year, or are no longer farming, please return the survey uncompleted and indicate why: (Check one)

[] I already completed and returned the survey earlier this year [] I am no longer farming

All other registered NS farmers are asked to complete the attached survey. It should take less than 30 minutes. This survey is voluntary. You have the right not to answer any question. Please ensure that the person completing the survey is the owner of the farm and is over 18 years of age. Please mail your responses in the addressed, postage-paid envelope provided by December 14, 2012.

The risk is considered to be minimal. The main discomfort for this study is the time requirement. You will not be compensated. By returning the survey you are consenting to the use of the information you have provided. This project is planned for completion in 2013. All surveys will be stored in a secure work space. The surveys will be destroyed five years after publication of the research.

Please contact me at baileyj@dal.ca, phone (902)896-4473 with any questions. If you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director of Dalhousie University's Office of Human Research Ethics Administration, for assistance at (902)494-1462, Catherine.connors@dal.ca. For long distance calls, you may call collect.

Thank you for participating in this survey. Your input is greatly appreciated. Please mail your responses in the addressed, postage-paid envelope provided by **December 14, 2012**.

Section A Introduction

A.1. What is your gross income percentage by commodity? Indicate approximate % where applicable (e.g. Beef 75% Hogs 25%)

___ Dairy	___ Mink	___ Honey, bees, pollination
___ Beef	___ Fox	___ Greenhouse crops
___ Hogs	___ Apples	___ Forages
___ Eggs	___ Blueberries	___ Grains
___ Chicken	___ Strawberries	___ Custom work
___ Turkey	___ Vegetable crops	___ Other ___________________
___ Sheep/lambs	___ Maple	___ Other ___________________

A.2. What are your **top three** concerns with regards to energy usage on your farm? Please **rank** 1, 2, 3 with 1 being your top concern.

___ Availability of energy sources	___ Equipment reliability
___ Cost to operate (e.g. electricity/fuel bills)	___ Power reliability (power outages)
___ Cost to purchase new efficient equipment	___ Self-sufficiency
___ Environmental concern	___ Other______________________

A.3. Approximately, how much money did you spend on energy on your farm in 2011?

Diesel	$______________	Propane	$______________
Electricity	$______________	Wood	$______________
Gasoline	$______________	Other ___________	$______________
Natural gas	$______________	___________	$______________
Oil (heating)	$______________	___________	$______________

A.4. Have you had some level of support to evaluate your energy options? Check **all** that apply.

[] Energy audit with report	[] Farm visit by a professional
[] Equipment specific review (e.g. lighting)	[] Information provided by a professional

A.5. In the past five years, have you done any new construction at your farm? [] yes [] no

A.6. In the past five years, have you done any renovations at your farm? [] yes [] no

A.7. Please indicate your age range. Please select **one**.

[] Under 35 years [] 35 to 54 years [] 55 years and over

A.8. Please indicate your total farm receipts for 2011. Please select **one**.

[] under $10,000	[] $50,000 - $99,999	[] $500,000 or $999,999
[] $10,000 to $24,999	[] $100,000 - $249,999	[] $1,000,000 to $1,999,999
[] $25,000 - $49,999	[] $250,000 - $499,999	[] Over $2,000,000

Section B Energy Efficiency and Conservation

B.1. What types of energy conservation and energy efficiency options have you used on the farm in the past five years? Please check **all** that apply. **If you do not use energy conservation/efficiency options on your farm please go to Section C.**

[] Efficient fans	[] Efficient windows/doors	[] Thermostat
[] Efficient furnace	[] Heat exchanger (e.g. plate cooler)	[] Variable speed drive
[] Efficient lighting	[] Heat recovery (e.g. heat reclaimer)	[] Zero-energy waterer
[] Efficient motors	[] Insulation	[] Other ____________
[] Efficient vehicle	[] Natural ventilation	[] Other ____________

B.2. Please provide a brief description of **one** of the energy upgrades you selected above.

____
____
____
____
____
____
____

B.3. What were your reasons for making the upgrade you described in question B.2? Check **all** that apply.

[] I was building new	[] To improve operating cost stability
[] I was renovating	[] To improve production
[] It is a regulatory requirement	[] To improve reputation
[] It is what other farms are doing	[] To improve safety
[] It was a necessity	[] To improve the work environment
[] It was recommended	[] To improve water quality
[] There were grants/rebates	[] To reduce noise
[] To be innovative	[] To reduce waste
[] To be self-sufficient	[] To save energy
[] To decrease air emissions	[] To save money
[] To improve animal welfare	[] To save time
[] To improve operating cost predictability	[] Other___________________

B.4. Please indicate your main reason from question B.3 by **circling one** of the items you selected above.

B.5. Did you consider any other technologies instead of the one you described in question B.2? Check **one**. [] yes [] no

B.6. If you checked '**yes**' in question B.5, please provide a brief description of the technologies you considered as alternatives. If you selected '**no**' in question B.5, please go to question B.9.

____
____
____
____

B.7. If you checked '**yes**' in question B.5, why did you pick that technology over the alternatives? Please check **all** that apply.

[] Availability	[] Functionality	[] Lower maintenance
[] Avoid inspection/regulation	[] Grants/rebates	[] Lower risk
[] Best in the long term	[] Innovative technology	[] More energy-efficient
[] Best in the short term	[] It is better for animal welfare	[] Personal preference
[] Better for the environment	[] It is safer	[] Practicality
[] Better payback	[] It is what other farms are doing	[] Proven technology
[] Buy local	[] It was recommended	[] Simplicity
[] Compatibility	[] Less noise	[] Technology appearance
[] Convenience	[] Less waste	[] Technology reputation
[] Durability	[] Longevity	[] Warranty
[] Familiarity	[] Lower capital cost	[] Other_____________

B.8. Please indicate your main reason from question B.7 by **circling one** of the items you selected above.

B.9. Did anyone influence your decision to make the change you described in question B.2? Check **one**.

[] yes [] no

B.10. If you answered '**yes**' in question B.9, who influenced your decision to make the change you described in question B.2? Please check **all** that apply. If you answered '**no**' in question B.9, please go to question B.12.

[] AgraPoint	[] Family/friends	[] NSFA
[] Consultant	[] Farmers/peers	[] Provincial government
[] Contractor	[] Federal government	[] University/college
[] Efficiency NS	[] Industry association	[] Utility
[] Employee	[] Manufacturer	[] Vendor
[] Energy professional	[] Municipal government	[] Other______________

B.11. Please indicate your main influencer from question B.10 by **circling one** of the items you selected above.

B.12. Which methods of information delivery did you use to get information to make the upgrade you described in question B.2? Please check **all** that apply.

[] Conference	[] I visited other farms	[] Telephone
[] Email	[] Internet	[] Tradeshow
[] Energy audit	[] Meeting	[] Workshop
[] Factsheets	[] Someone visited my farm	[] Other_____________

B.13. Did you encounter any problems/obstacles when making the upgrade you described in question B.2? Check **one**.

[] yes [] no

B.14. If you answered '**yes**' in question B.13, what problems/obstacles did you encounter? Please check **all that apply**. If you answered '**no**' in question B.13, please go to Section C.

[] Availability of materials	[] Lack of funding	[] Mixed messages
[] Contractor availability	[] Lack of information	[] Red tape
[] Lack of capital	[] Lack of labour	[] Scheduling conflict
[] Lack of financing	[] Lack of time	[] Other ____________

Section C Alternative Energy Options

C.1. What types of alternative energy technology have you used on the farm in the past five years? Please check **all** that apply. **If you do not use alternative energy on your farm, please go to Section D.**

[] Agricultural biomass (e.g. grass)	[] Hydroelectric	[] Tidal
[] Air-source heat pump	[] Passive solar heating	[] Wind power
[] Biofuel (e.g. biodiesel)	[] Photovoltaic (solar panel)	[] Wood biomass
[] Biogas (e.g. anaerobic digestion)	[] Solar air heating	[] Other ______________
[] Ground-source heat pump	[] Solar hot-water heating	[] Other ______________

C.2. Please provide a brief description of **one** of the energy upgrades you selected above.

____
____
____
____
____
____
____

C.3. What were your reasons for making the upgrade you described in question C.2? Check **all** that apply.

[] I was building new	[] To improve operating cost stability
[] I was renovating	[] To improve production
[] It is a regulatory requirement	[] To improve reputation
[] It is what other farms are doing	[] To improve safety
[] It was a necessity	[] To improve the work environment
[] It was recommended	[] To improve water quality
[] There were grants/rebates	[] To reduce noise
[] To be innovative	[] To reduce waste
[] To be self-sufficient	[] To save energy
[] To decrease air emissions	[] To save money
[] To improve animal welfare	[] To save time
[] To improve operating cost predictability	[] Other___________________

C.4. Please indicate your main reason from question C.3 by **circling one** of the items you selected above.

C.5. Did you consider any other technologies instead of the one you described in question C.2? Check **one**. [] yes [] no

C.6. If you checked '**yes**' in question C.5, please provide a brief description of the technologies you considered as alternatives. If you selected '**no**' in question C.5, please go to question C.9.

____
____
____
____
____

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C.7. If you checked '**yes**' in question C.5, why did you pick that technology over the alternatives? Please check **all** that apply.

[] Availability	[] Functionality	[] Lower maintenance
[] Avoid inspection/regulation	[] Grants/rebates	[] Lower risk
[] Best in the long term	[] Innovative technology	[] More energy-efficient
[] Best in the short term	[] It is better for animal welfare	[] Personal preference
[] Better for the environment	[] It is safer	[] Practicality
[] Better payback	[] It is what other farms are doing	[] Proven technology
[] Buy local	[] It was recommended	[] Simplicity
[] Compatibility	[] Less noise	[] Technology appearance
[] Convenience	[] Less waste	[] Technology reputation
[] Durability	[] Longevity	[] Warranty
[] Familiarity	[] Lower capital cost	[] Other_____________

C.8. Please indicate your main reason from question C.7 by **circling one** of the items you selected above.

C.9. Did anyone influence your decision to make the change you described in question C.2? Check **one**.

[] yes [] no

C.10. If you answered '**yes**' in question C.9, who influenced your decision to make the change you described in question C.2? Please check **all** that apply. If you answered '**no**' in question C.9, please go to question C.12.

[] AgraPoint	[] Family/friends	[] NSFA
[] Consultant	[] Farmers/peers	[] Provincial government
[] Contractor	[] Federal government	[] University/college
[] Efficiency NS	[] Industry association	[] Utility
[] Employee	[] Manufacturer	[] Vendor
[] Energy professional	[] Municipal government	[] Other______________

C.11. Please indicate your main influencer from question C.10 by **circling one** of the items you selected above.

C.12. Which methods of information delivery did you use to get information to make the upgrade you described in question C.2? Please check **all** that apply.

[] Conference	[] I visited other farms	[] Telephone
[] Email	[] Internet	[] Tradeshow
[] Energy audit	[] Meeting	[] Workshop
[] Factsheets	[] Someone visited my farm	[] Other_____________

C.13. Did you encounter any problems/obstacles when making the upgrade you described in question C.2? Check **one**.

[] yes [] no

C.14. If you answered '**yes**' in question C.13, what problems/obstacles did you encounter? Please check **all that apply**. If you answered '**no**' in question C.13, please go to question C.15.

[] Availability of materials	[] Lack of funding	[] Mixed messages
[] Contractor availability	[] Lack of information	[] Red tape
[] Lack of capital	[] Lack of labour	[] Scheduling conflict
[] Lack of financing	[] Lack of time	[] Other ____________

C.15. If you replaced existing equipment when making the upgrade you described in question C.2, what energy source did you replace/offset/supplement? Check **all** that apply.

[] Diesel	[] Gasoline	[] Oil	[] Wood	[] N/A
[] Electricity	[] Natural gas	[] Propane	[] Other _________	

Section D Future Changes

D.1. What type of energy conservation/efficiency and renewable energy options are you **interested in using** on your farm in the next five years? Please check **all** that apply. If you are not interested in any energy conservation and renewable energy options, please go to question D.4.

Energy conservation options	**Alternative energy options**
[] Behaviour (e.g. turning lights off)	[] Agricultural biomass (e.g. grass)
[] Efficient fans	[] Air-source heat pump
[] Efficient furnace	[] Biofuels (e.g. biodiesel)
[] Efficient lighting	[] Biogas (e.g. anaerobic digestion)
[] Efficient motors	[] Ground-source heat pump
[] Efficient vehicle	[] Hydroelectric
[] Efficient windows/doors	[] Leasing land for renewables
[] Farming techniques (e.g. no-till farming)	[] Passive solar heating
[] Heat exchanger / heat recovery	[] Photovoltaic (solar panel)
[] Insulation	[] Solar air heating
[] Natural ventilation	[] Solar hot-water heating
[] Thermostat/controller	[] Tidal
[] Variable speed drive	[] Wind power
[] Zero energy waterer	[] Wood biomass
[] Other ___________________________	[] Other ____________________

D.2. Please indicate the energy option you are most interested in by **circling one** of the options you selected above. Please use this selection as an example for question D.3.

D.3. What would influence your decision to implement the future energy conservation/efficiency upgrades or renewable energy option you selected in question D.2.? Please **rate** from very unlikely to influence (1) to very likely to influence (5). Circle one for each option.

	Very unlikely				Very likely
A demonstration site	1	2	3	4	5
A regulatory requirement	1	2	3	4	5
Access to financing	1	2	3	4	5
Access to information	1	2	3	4	5
An energy audit program	1	2	3	4	5
Cost savings	1	2	3	4	5
Discounts on products	1	2	3	4	5
Grants for implementing upgrades	1	2	3	4	5
Workshops/education sessions	1	2	3	4	5
Other______________________	1	2	3	4	5

D.4. When are you hoping to retire? Within the next….(Please check **one**)

[] 1 to 5 years [] 6 to 10 years [] 11 to 15 years [] 16 to 20 years [] 21 years +

D.5. When you retire, what are your plans for the farm? Please check **one**.

[] Not applicable [] Sell or transfer to family [] Shut down farm
[] Not sure [] Sell to non-family [] Other_____________

Section E Comments and Ideas

E.1. If you would like to provide more information on energy conservation/efficiency upgrades and/or renewable energy upgrades you have made or plan on making, please use the space below.

E.2. If you have any ideas on ways to incorporate energy sustainability into NS farm decision-making when selecting energy conservation/efficiency and renewable energy options describe them below.

Thank you for participating in this survey. Your input is greatly appreciated. Please mail your responses in the addressed, postage-paid envelope provided by **December 14, 2012**.

If you would like to participate in future research associated with this study, please contact me at: baileyj@dal.ca or 896-4473

APPENDIX C CASE STUDY INTERVIEW GUIDE

Interview Guide for Farmers

Background Questionnaire

1. Gender Male/Female
2. Age range 18-25 26-35 36-45 46-55 55+
3. Primary Farm Type ____
4. Secondary Farm Type____
5. Farm Size (Gross Farm receipts) range____________________________________
6. Farm location (county)______________________________________

Opening Question

1. What is your name and the name of your business?

Introduction Question

2. Tell me about a recent energy improvement you have made on your farm? (*start with one but allow for more than one)*

Transition Question

4. What were your reasons for considering energy changes to your operation?
   What were the most important reasons for you to make a change? (e.g. cost savings)
   Was the environment one of your considerations? (e.g. water, land, air, GHG issues)
   What about social or political considerations such as safety or labor/time requirements?
   Did you set any goals prior to making an upgrade? If so, what were your goals?

Key Questions

4. How have you gone about making your decision?
   What information did you gather to make your decision?
   Where did you go to get information?
   Did you have an energy audit/review?
   Did you compare any options?
   Did you consider or do multiple projects? If so, how did you pick the ones to do first?
   Can you think of ways to improve the decision-making process?
5. Did the upgrade meet your goals/expectations?
   Has the energy upgrade made any improvements in your operation?
   Have you measured any improvements? If so, how? (e.g. data collection)
   Did you measure a baseline for comparison?

Ending Question

6 Do you have any plans for future energy upgrades?
   What are your goals for this upgrade? (e.g. to save money)
   What problems/obstacles have you encountered? (e.g. mixed messages, time frame, financing, funding, contractor availability, labor, etc…)

Concluding Question

7. Is there anything else that you would like to add that we haven't covered?