5-2009

Energy Efficiency Projects in Pennsylvania Small Businesses

Joseph J. Lavin
University of Pennsylvania

Presented to the Faculties of the University of Pennsylvania in Partial Fulfillment of the Requirements for the Degree of Master of Environmental Studies 2009.

Energy Efficiency Projects in Pennsylvania Small Businesses

Abstract

Energy efficiency will be an important contributor to reduction of greenhouse gases (GHGs) and will help reduce America's dependence on energy from the Middle East. The Pennsylvania Small Business Development Center (SBDC) Environment Management Assistance Program (EMAP) makes energy efficiency project recommendations to clients who request assistance. EMAP strives to become more effective in their recommendations. Based on EMAP data from August 2007 to December 2008, they want to determine if there is a relationship between a project recommendation and its implementation.

The literature has examined results of other voluntary energy efficiency programs – Industrial Assessment Centers, Green Light, and Energy Star. Many projects were not implemented in spite of having a positive economic effect on the respective businesses. This phenomenon is called the energy efficiency paradox. Are these market failures of imperfect information, bounded rationality, or the principal-agent problem?

Chi-squared testing was used to assess whether dependency exists between various categories of a project and the decision to implement or not. The hypothesis developed from early results and confirmed by testing is: Grant money to small businesses in Pennsylvania is the single biggest factor in the decision to implement energy efficiency projects.

Analysis of data supports the conclusions from an earlier survey by researchers at the University of Pittsburgh with small businesses in western Pennsylvania during 1976/77 (Doctors, Fahey, & Patton, 1978). The biggest obstacles to energy efficiency investments are lack of capital and the perception that the potential energy savings were not worth the effort.

Disciplines

Environmental Sciences | Physical Sciences and Mathematics

Comments

Presented to the Faculties of the University of Pennsylvania in Partial Fulfillment of the Requirements for the Degree of Master of Environmental Studies 2009.

Energy Efficiency Projects in Pennsylvania Small Businesses

Primary Reader: Stanley L. Laskowski
Secondary Reader: Christopher J. Lynch

Joseph J. Lavin
May, 2009

Table of Contents

Executive Summary

Energy efficiency will be an important contributor to reduction of greenhouse gases (GHGs) and will help reduce America's dependence on energy from the Middle East. The Pennsylvania Small Business Development Center (SBDC) Environment Management Assistance Program (EMAP) makes energy efficiency project recommendations to clients who request assistance. EMAP strives to become more effective in their recommendations. Based on EMAP data from August 2007 to December 2008, they want to determine if there is a relationship between a project recommendation and its implementation.

The literature has examined results of other voluntary energy efficiency programs – Industrial Assessment Centers, Green Light, and Energy Star. Many projects were not implemented in spite of having a positive economic effect on the respective businesses. This phenomenon is called the energy efficiency paradox. Are these market failures of imperfect information, bounded rationality, or the principal-agent problem?

Chi-squared testing was used to assess whether dependency exists between various categories of a project and the decision to implement or not. The hypothesis developed from early results and confirmed by testing is: **<u>Grant money to small businesses in Pennsylvania is the single biggest factor in the decision to implement energy efficiency projects</u>.**

Analysis of data supports the conclusions from an earlier survey by researchers at the University of Pittsburgh with small businesses in western Pennsylvania during 1976/77 (Doctors, Fahey, & Patton, 1978). **The biggest obstacles to energy efficiency investments are lack of capital and the perception that the potential energy savings were not worth the effort.**

I. Introduction.

Why does America need energy efficiency? Energy efficiency can help reduce our greenhouse gas emissions and reduce our dependence on energy from the Middle East. The scientific community has reached a consensus that unless we reduce our greenhouse gas emissions substantially, global climate change will be accelerated. The economic impact to the world could have great consequences (Stern, 2007). CO_2 is the most significant greenhouse gas (GHG). The increase of CO_2 in the atmosphere comes primarily from mankind's use of fossil fuels for energy. As we transition to a lower-carbon economy, there is a need to increase energy efficiency along with conservation and the adoption of clean technologies for power, heat, and transportation (Stern, 2007). Energy efficiency is using less electricity, oil, or gas while receiving the same energy service, e.g. using less electricity but receiving the same amount of heating or cooling from our systems. As Sir Nicholas Stern (2007), Head of the UK government Economic Service, and a former Chief Economist of the World Bank says, "Energy efficiency is one way to meet climate change and energy security objectives at the same time. Policies to promote efficiency have an immediate impact on emissions. More efficient use of energy reduces energy demand and puts less pressure on generation and distribution networks and lowers the need to import energy or fuels." Conservation is using less energy service, e.g. lowering the thermostat in winter and increasing it in summer. Clean technologies are renewable energy sources such as solar, wind, biomass, geothermal, or marine. Energy efficiency could reduce as much as 30% of our current energy use with the technology available today (Mims, Bell, & Doig, 2009). The International Energy Agency (IEA) estimates that manufacturers can reduce from 18-26% their energy usage based on proven technology excluding recycling and energy recovery (Tam, 2008).

Energy efficiency programs started in the 1970s when the U.S. first made steps toward weaning ourselves off of foreign oil. Researchers at the University of Pittsburgh surveyed small manufacturers in western Pennsylvania to determine their response to the energy & weather crisis in 1976/77. Neither the size of the firm nor the energy intensity of the activities seemed to have any impact on energy efficient technology (EET) investments. The biggest obstacles found to these investments were lack of capital and a perception that potential energy savings were not worth the effort (Doctors et al., 1978). This is still the case more than thirty years later as this paper will demonstrate.

Various voluntary energy efficiency programs have been analyzed by economists for their effectiveness. The U.S. Department of Energy (DOE) started their Industrial Assessment Center (IAC) program in 1976. IAC is administered through 26 universities for 500 small and medium-sized manufacturers each year at a cost of about $7,000 per audit. This program has completed over 10,000 energy audits in the last two decades with over 70,000 individual projects, but only about half of the projects were implemented (Anderson & Newell, 2004). The Green Lights program of the U.S. Environmental Protection Agency (EPA) started in 1991 to assist industry to change to energy efficient lighting. The ability to reduce market failures related to imperfect information and bounded rationality were part of the success of these voluntary programs (Howarth, Haddad, & Paton, 2000). Started by the EPA in 1992 and partnered with the DOE in 1996, the Energy Star program was developed to inform businesses and consumers about energy-efficient solutions. In 2002, the program was extended from energy efficient products to energy-efficient production. An energy performance indicator (EPI) was created as a benchmarking tool at the sector specific plant level based on the relationship between the level of energy use and the level and type of various production activities, quality of material, and external factors such as weather. Recognition is given for those in the 75th percentile (Boyd, Dutrow, & Tunnessen, 2008). This is an excellent start but benchmarking should not be limited to a particular industry sector or mediocre sectors will stay mediocre. Benchmarking should be based ultimately on those who perform a process best. Processes are common across sectors. For instance, Dell is known for the efficiency of its supply chain management system and that is why scores of executives from major firms in many different types of industries visit Dell every year to study their methods.

However, both engineers and economists are puzzled over the lack of investment in energy efficiency technology. Why don't firms invest in EET if there is a positive Net Present Value (NPV) for a project? This phenomenon is called the energy-efficiency paradox. There are many examples of energy-saving technologies that have not been adopted in spite of the fact that there is less risk than other investments and a positive NPV can be shown using even a relatively high discount rate (DeCanio & Watkins, 1998).

This paper will examine data from the Environmental Management Assistance Program (EMAP) of the Pennsylvania Small Business Development Centers (SBDC), another voluntary program. EMAP consultants perform energy audits and assist clients in applying for state grants where applicable. EMAP desires to improve their programs and determine if there are relationships between a recommended project and the decision to implement or not implement that project.

1.1 Factors affecting the adoption of EET

Adoption of EET or any new technology follows an s-shaped or 'sigmoid' curve. Any policy to increase the profitability of a technology will speed it diffusion (Jaffe & Stavins, 1994).

However there are market barriers to energy-efficient investment which include: imperfect information, bounded rationality, and principal-agent problems (Decanio, 1993; Sanstad & Howarth, 1994; Schleich & Gruber, 2008).

1.1.1 Imperfect information

Is the low adoption rate partially due to the lack of quantification of the non-energy benefits? Are savings understated by using only energy cost reduction? Waste reduction and pollution prevention can enhance profitability. Evidence from several case studies suggests that investment decisions in EET can be better understood as part of a broader set of parameters that affect a company's productivity and profitability (Pye & McKane, 2000). Too simplistic a benefit-cost analysis for significant capital investments might only add to the uncertainty of the project. In addition to the lifetime benefits the decision-maker needs to know the lifetime costs which in addition to operations and maintenance might include significant transaction costs associated with the investment (Stern, 2007). Another possible reluctance to invest in EET is the fact that future technologies are unknown and investments in these new EETs are at least partially irreversible. Are decisions based on short payback periods to limit risk rather than Net Present Value (NPV) criteria? Are these seen as only peripheral investments and therefore need to use a higher discount rate (van Soest & Bulte, 2001)? Company specific characteristics influence membership in these voluntary programs. EPA's Green Lights program shows a strong association between membership and good financial performance of a firm. Certain industry sectors also have diffused information to their member firms which in turn leads to greater participation (DeCanio & Watkins, 1998).

1.1.2 Bounded rationality

Lack of adoption of specific EET such as energy efficient motors may be related a purchasing bias to find the cheapest solution to a problem and ignore the total life-cycle costs. Costs are initially higher for these motors by 15-30% but the payback comes from energy savings over the useful life of the motors (Bartos, 2005).

Is there a champion within the company management who views energy efficiency as a high priority? The existence of such a champion was found to be the best single indicator of positive action (Goitein, 1989).

Traditional benefit-cost analysis (BCA) makes a number of assumptions about human preferences but doesn't look into responses to non-marketing incentives. Preferences could include risk aversion. Economic studies have shown large discrepancies exist between the willingness-to-accept (WTA) a loss and the willingness-to-pay (WTP) for a gain. WTA may be up to five times greater than the WTP. Energy efficiency projects require a WTP in order to get a gain (more profits from less energy costs) but a WTA the status quo, i.e. a loss but no risk, might be greater. There are also preferences which show a non-linear and non-uniform discounting of the future (Gowdy, 2007). If the payback period is long, is our risk aversion so great that we would avoid the benefits of EET because of the unknown future energy costs? The ability to forecast accurately is affected by time. The farther we forecast in the future, the less accurate the forecast. Most managers will focus on the firm's core processes and the major cost drivers. EET is a peripheral cost in most cases (Doctors et al., 1978; Schleich & Gruber, 2008), e.g. in restaurants energy costs are usually less than 5% of total costs; labor, food, and rent are more important.

1.1.3 Principal-agent problem

Another name for this could be landlord-tenant or investor-user problem. If the lease period is less than the payback period of a project, this should be a knock-out factor due to the increased risk that the lease cannot be renewed or only at a much higher rate. In a study of energy use by apartment tenants some of the complexities of the problem were identified. If the landlords pay utilities, tenants keep the apartments warmer and waste energy. On the other hand, if tenants pay for the utilities, there is little incentive for the landlords to invest in EET (Levinson & Niemann, 2004). However, the duration of rental agreements for commercial sites is usually longer than for households which should help mitigate the problem (Schleich & Gruber, 2008). Are transaction cost and asymmetric information at the root of the investor-user dilemma (Sanstad & Howarth, 1994; Schleich & Gruber, 2008)?

A majority of the small business retailers lease their space and present this landlord-tenant problem. Grant application with the PADEP for projects involving windows, doors, insulation, lighting system upgrades, and HVAC (heating, ventilation, and cooling) systems must include a Land Owner Consent Form if applicant is not the owner (PADEP, 2008; PADEP, 2009).

The principal-agent dilemma can also significantly slow implementation. Plant managers who are not the owners required a year to get a capital investment in the budget in 70% of the cases studied (Goitein, 1989).

II Energy Efficiency projects in Pennsylvania.

The Environmental Management Assistance Program (EMAP) is part of the State of Pennsylvania Small Business Development Centers (SBDC).As part of the job as an EMAP consultant, energy efficiency audits are performed. The lists of projects given to their clients are entered into a data base by the 11 EMAP consultants throughout the State of Pennsylvania. For each project the following information is entered:

- client name (confidential – not on the data based used for analysis)
- client identification (ID) number
- actual energy cost savings
- energy savings units
- other energy savings units
- actual avoided energy use
- actual project implementation cost
- reason not implemented
- recommendation conclusion date
- status – implemented, partially implemented, not implemented, or blank
- payback period (years)
- estimated project cost
- estimated project savings
- estimated energy savings (units)
- estimated energy savings
- energy type – electricity, oil, gas, other, or blank
- energy savings category (project type)

- energy savings other
- date recommendation made
- recommendation description
- client Standard Industrial Classification (SIC) code
- client SIC description
- product North American Industry Classification System (NAICS) code
- NAICS description

In addition the Assistant Director of EMAP indicated in the data file used if a Small Business Advantage Grant (SBAG) was applied for (1 or 0), if a SBAG was received (1 or 0), and date SBAG received. Many of the categories cannot be filled in by the consultant until the follow-up periods of two weeks, one month, three months, six months, and twelve months. This new record keeping system was implemented in August 2007 and the consultants are constantly updating information. In my discussions with the consultants, one of the difficulties in getting much of the data was the fact that many clients do not respond to emails or phone calls for additional information after the original audit. This file was made available to me as a Excel spreadsheet minus the client names in order to maintain their confidentiality. The basis of analysis in section III comes from the data in this file.

Energy efficiency audits are performed by eleven EMAP consultants located throughout the state of Pennsylvania. The consultants start an audit by reviewing energy utility bills for the last year. Then they compare the usage to a base standard for that particular type of business and size. Most recommendations start off with the “low-hanging fruit” such as lighting systems, light switch motion sensors, programmable thermostats, and upgrades to Energy Star equipment. For any complex technical issues they would refer their client to a qualified contractor. The EMAP consultants are familiar with the details of SBAG program and work with their clients if the project is eligible. The consultants are also adapting to the new Small Business Energy Efficiency Grant (SBEEG) program. The consultants present their findings to the client and follow-up at appropriate intervals. Energy price spikes as occurred in the summer of '08 bring a flurry of activity. When electricity rates are deregulated in Pennsylvania in 2010, rates are expected to spike by 25-30% or more. Another spike in activity can be anticipated.

2.1 Grant programs

The Small Business Advantage Grant (**SBAG**) program is administered by the Small Business Ombudsman's Office within the Pennsylvania Department of Environmental Protection (DEP). The fifth round of the SBAG program was initiated on July 21, 2008 and accepted applications until August 29, 2008. One million dollars was provided by the State for 50% matching grants up to a maximum of $7,500 to implement pollution prevention or energy efficiency projects. Projects are reviewed in the order in which they are received – first come, first received funding criteria. The following criteria apply to the 2008 program: 1) An eligible project must save the business at least 15% annually in energy or pollution related expenses. 2) Residential rental units and dwellings are ineligible. 3) Weather envelope projects are not eligible including roofing, siding, windows, or doors. 4) Projects involving the purchase and installation of high purity nitrogen tire inflation systems for use by small business fleet vehicles are eligible. Certain indoor environment projects; such as lighting system upgrades; heating, ventilation, and cooling (HVAC) systems; air curtains; and insulation are only eligible if applicant owns the building or includes a Land Owner Consent Form signed by the building owner. Reimbursement is made after the project is completed. A one-year follow-up report is required with actual costs and actual quantities of energy saved (PADEP, 2008).

The Small Business Energy Efficiency Grant (**SBEEG**) program was started on January 12, 2009 and will run to May 1, 2009. It is also under the administration of the Pennsylvania DEP. The program provides Pennsylvania small businesses an opportunity to receive a 25% matching grant up to $25,000. Similar to the SBAG program, grants are awarded on a first come, first serve basis. Key factors of eligibility are: 1) Annual energy savings must be at least 20% (up from the 15% in SBAG). 2) The project must save the small business at least $1,000 per year in energy costs (about 50% of the SBAG grants received by EMAP clients would not qualify). 3) Project must be completed by October 30, 2009. 4) Energy Star equipment must be installed if applicable. 5) Failure to provide the one-year follow-up within 13 months of completion will result in the applicant being barred from future financial assistance program of Pennsylvania DEP (PADEP, 2009).

III. Analysis of EMAP data.

EMAP desires to improve the efficiency of the energy audits they perform. What relationships exist between the recommendations and the implementation of a project? Of the 1020 records of projects received, 371 indicated they were complete, i.e. status field was not blank. Of the 371 projects, 222 were implemented, 33 partially implemented, and 116 not implemented. For the 116 projects that were not implemented the reason given in the reason not implemented column is as follows: 12 businesses closed or were not started, 1 alternative solution found, 14 time, 26 money, 52 other, and 11 blank. After adjusting for businesses that don’t exist anymore, half of the reasons given for not implementing a project is “other.” A further analysis of the “not implemented” category with the payback period not blank shows:

Payback period & reason not implemented				
Count of Payback (years)	Column Labels			
Row Labels	Money	Other	Time	Grand Total
Group1 0 to 1	2	15	4	21
Group2 >1 to 3	3	11		14
Group3 >3 to 6	2	9	1	12
Group4 >6	11	6	2	19
Grand Total	18	41	7	66

When the payback period is short, i.e. higher profitability, the reason given for not implementing a project is "other" and when the payback is longer the reason shifts to money. These numbers support the conclusion of Doctors et al (1978) that the biggest obstacles to energy efficiency investment are lack of capital and the perception that the potential energy savings were not worth the effort. Could "other" indicate that the transactional costs of the project are high or is it a case of the WTA trumping the WTP?

3.1 Chi-square test.

I used a chi-square statistic to examine whether there is a relationship between two categories. The chi-square test is a test for independence. It tests the null hypothesis that the variables are independent, i.e. that there is no statistical relationship between them. The chi-square test relies of the difference between observed and expected values in each cell. The expected value is based on proportionality; each cell is calculated by the total of the row times the total of the column divided by the grand total. A p-value is then determined by Excel based on this chi-square test, the squared difference between observed and expected values in each cell, and the degrees of freedom. If the p-value is < .05, it is common to reject the null hypothesis and conclude that the variables are not independent (Boslaugh & Watters, 2008). Five categories were chosen to test against the status category in consultation with the Director and Assistant Director of EMAP. These categories were picked because of their possible influence on a decision to implement or not. The five categories are: energy type, project type, payback period, estimated cost savings, and estimated project cost. Energy type and project type are categorical while payback period, estimated cost savings, and estimated project cost are numerical. To perform the chi-square test the numerical categories were grouped as follows:

Grouping of numerical categories			
	Estimated savings	Estimated cost	Payback period (years)
Group 1	\$0 to \$200	\$0 to \$500	0 to 1
Group 2	>\$200 to \$1,000	>\$500 to \$5,000	>1 to 3
Group 3	>\$1,000 to \$2,500	>\$5,000 to \$15,000	>3 to 6
Group 4	>\$2,500	>\$15,000	>6

The most significant factor found in the analysis is whether or not a project was eligible for and received a SBAG. Chi-squared analysis was performed on each category with SBAG included and SBAG excluded. Twelve projects where the business no longer exists were also removed from each since factors beyond the energy efficiency recommendations were operative. This would reduce the number of projects to analyze from 371 to 359. Blanks in the data base for each category were also dropped. With each of the five categories analyzed reconciliation will be made back to 359. The main hypothesis to be tested is: **Grant money to small businesses in Pennsylvania is the single biggest factor in the decision to implement energy efficiency projects.**

3.1.1 Energy type

The projects analyzed for energy type vs. status are found in Table 1. Starting with 359 records and excluding any record with a blank in energy type, this was 300 records. In addition, I excluded projects with "other" listed as the energy type since this is a small number (10) and would weaken the chi-squared analysis. The chi-squared test analysis with energy type used 290 records (359-59-10=290). As recorded in Table 1, the chi-squared test results p-value with and without the SBAG projects are both > .05, the null hypothesis holds and the two factors are independent.

Table 1

Energy Type vs. Status

Observed

Count of Energy Type	Column Labels			
Row Labels	Implemented	Not Implemented	Partially Implemented	Grand Total
Electricity	99	62	19	180
Fuel oil	25	17	4	46
Natural Gas	48	11	5	64
Grand Total	172	90	28	290

Expected

Count of Energy Type	**Column Labels**			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Electricity	107	56	17	180
Fuel oil	27	14	4	46
Natural Gas	38	20	6	64
Grand Total	**172**	**90**	**28**	**290**

chi test result p-value	0.06161299

Energy Type vs. Status w/o SBAG

SBAG Received (Multiple Items)

Observed

Count of Energy Type	Column Labels			
Row Labels	Implemented	Not Implemented	Partially Implemented	Grand Total
Electricity	52	60	18	130
Fuel oil	9	17	2	28
Natural Gas	17	9	4	30
Grand Total	78	86	24	188

Expected

Count of Energy Type	**Column Labels**			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Electricity	54	59	17	130
Fuel oil	12	13	4	28
Natural Gas	12	14	4	30
Grand Total	**78**	**86**	**24**	**188**

chi test results	0.188458097

If we combine implemented and partially implemented status columns, the results are a p-value of 0.0239 for all projects and a p-value of 0.2804 for all projects excluding those that received a SBAG. If we include the projects that received a grant, independency is not confirmed. This is a pattern we will see with all the other categories as well. When projects that received a SBAG are excluded the relationship between status and the various categories is independent. Each of the categories tested will show a significant p-value <.05 when the grants are included and a p-value >.05 when the grants are excluded. This indicates that there is a relationship of dependency between the category and the action taken only when grants are included. When the SBAG projects are removed in all five cases the p-value indicates that the respective category and the action taken are independent of each other.

3.1.2 Project type

The second category tested is project type also referred to as "cost savings category". Table 2 reflects the chi-test p-value for this category vs. status. Certain records are excluded from the analysis. Starting with 359, I excluded those records that had a blank in the cost savings category. This was 7 records. Next, I excluded two small categories, "peak demand" with 6 records and "compressed air" with 3 records. The total records used for the chi-squared analysis was 343 (359-7-6-3=343).

The p-value from the chi-squared test when grants are included is 0.01260 and when grants are excluded it is 0.23222. Again, this shows dependency when the grants are included and independence when the grants are excluded.

Table 2

Project type vs. Status

Reason Not Implemented	(Multiple Items)

Observed

Count of Energy Savings Category	Column Labels			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Building Envelope	23	15	2	40
Equipment Upgrade	33	12	2	47
HVAC	87	30	7	124
Lighting	46	34	16	96
Other	23	8	5	36
Grand Total	**212**	**99**	**32**	**343**

Expected

Count of Energy Savings Category	Column Labels			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Building Envelope	25	12	4	40
Equipment Upgrade	29	14	4	47
HVAC	77	36	12	124
Lighting	59	28	9	96
Other	22	10	3	36
Grand Total	**212**	**99**	**32**	**343**

chi-test p-value	0.012601854

All 104 of the grants (SBAG) received and completed were included in the above analysis.

Project type vs. status w/o SBAG

Reason Not Implemented	(Multiple Items)
SBAG Received	(Multiple Items)

observed

Count of Status	Column Labels			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Building Envelope	16	14	2	32
Equipment Upgrade	19	12	2	33
HVAC	32	27	5	64
Lighting	32	34	15	81
Other	18	8	3	29
Grand Total	**117**	**95**	**27**	**239**

expected

Count of Status	Column Labels			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Building Envelope	16	13	4	32
Equipment Upgrade	16	13	4	33
HVAC	31	25	7	64
Lighting	40	32	9	81
Other	14	12	3	29
Grand Total	**117**	**95**	**27**	**239**

chi-test p-value 0.232223355

Examining the SBAGs completed combining the two categorical factors of project type and energy type, we find that the largest number of projects use electricity (about half) spread almost equally for equipment upgrades, HVAC, and lighting systems. HVAC projects represent more than half of the total grant projects. Fuel oil and natural gas projects are predominantly for HVAC systems. Two SBAGs were for "other" energy type which brings the total SBAGs completed to 104.

Small Business Advantage Grants

Reason Not Implemented	(Multiple Items)
Status	(Multiple Items)
SBAG Received	1

Count of Energy Savings Category	Column Labels			
Row Labels	**Electricity**	**Fuel oil**	**Natural Gas**	**Grand Total**
Building Envelope	1	1	6	8
Equipment Upgrade	13			13
HVAC	17	17	26	60
Lighting	15			15
Other	4		2	6
Grand Total	**50**	**18**	**34**	**102**

The three numerical categories (estimated savings, estimated cost, and payback period) have been grouped to do the chi-test analysis. These groupings were developed to give an overall balance to the various group when all records are included and to minimize small observed cells under 5 in the analysis. More than 20% of the cells with under 5 observations each would invalidate the results of the chi-square test (Boslaugh & Watters, 2008). However the balance of the groupings is not as good for the SBAG records by themselves.

Small Business Advantage Grants			
	Estimated savings	Estimated cost	Payback period
Group 1	12	5	10
Group 2	34	19	17
Group 3	26	48	28
Group 4	31	29	27
	103	101	82

3.1.3 Payback period

The payback period is calculated in years. This is a simple payback calculation by the consultant. Payback period = project cost / annual project savings. No discount rate is applied. The payback period is not automatically calculated. Payback period was blank in 140 of the 359 completed records. To reconcile back to the 359 records the following calculation show (359-140=219). In the records of the SBAG received, 8 records show adjustments by the consultants to reflect the payback for the owner after the grant money is received, e.g. if the savings were $2,522 annually and the cost of the project was $19,949; the payback period was recorded as 4.9 even though a simple payback calculation would be 7.9. Up to 50% or $7,500 is paid by the grant. This would not significantly alter the analysis. The chi-squared test p-value is .03544 with SBAG records included and .19814 when the SBAG records are removed. The pattern from the energy and project types continues with the SBAG as the most significant influence in determining the decision to implement or not. It should also be noted that 12 SBAG records were blank in the payback period. These records were not included in either set of analyses.

Table 3
Payback (years) vs. Status

Observed

Count of Payback (years)	Column Labels			
Row Labels	Implemented	Not Implemented	Partially Implemented	Grand Total
Group1 0.0 to 1.0	27	21	6	54
Group2 >1.0 to 3.0	31	13	4	48
Group3 >3.0 to 6.0	28	13	9	50
Group4 >6.0	48	18	1	67
Grand Total	134	65	20	219

Expected

Count of Payback (years)	**Column Labels**			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Group1 0.0 to 1.0	33	16	5	54
Group2 >1.0 to 3.0	29	14	4	48
Group3 >3.0 to 6.0	31	15	5	50
Group4 >6.0	41	20	6	67
Grand Total	**134**	**65**	**20**	**219**

chi-test p-value	0.035442741

SBAG Received (Multiple Items) **Payback vs. Status w/o SBAG**

Observed

Count of Payback (years)	Column Labels			
Row Labels	Implemented	Not Implemented	Partially Implemented	Grand Total
Group1 0.0 to 1.0	18	20	6	44
Group2 >1.0 to 3.0	15	13	3	31
Group3 >3.0 to 6.0	4	13	5	22
Group4 >6.0	13	16	1	30
Grand Total	50	62	15	127

Expected

Count of Payback (years)	**Column Labels**			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Group1 0.0 to 1.0	17	21	5	44
Group2 >1.0 to 3.0	12	15	4	31
Group3 >3.0 to 6.0	9	11	3	22
Group4 >6.0	12	15	4	30
Grand Total	**50**	**62**	**15**	**127**

chi-test p-value	0.198142983

3.1.4 Cost Savings

Cost savings is the indication of how much energy dollars are saved in a given year and no other savings such as improvements in productivity or reduction in operating costs are included. There are 102 records with blanks in cost savings. These were excluded from the analysis (359 – 102 = 257). There are 2 records that are blank in the cost savings field that received grants. Therefore the difference between the two chi-square analyses is 102 (104-2=102). In the chi-square test the p-value with SBAG is .00248 and without SBAG records is .18689. More evidence that the single biggest factor in decisions to implement or not is whether a grant is given.

Table 4
Cost Savings vs. Status

Observed

Count of Est. Cost Savings/year	Column Labels			
Row Labels	Implemented	Not Implemented	Partially Implemented	Grand Total
Group1 $0 to $200	27	24	7	58
Group2 >$200 to $1,000	49	35	11	95
Group3 >$1,000 to $2,500	37	9	4	50
Group4 >$2,500	43	7	5	55
Grand Total	156	75	27	258

Expected

Count of Est. Cost Savings/year	**Column Labels**			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Group1 $0 to $200	35	17	6	58
Group2 >$200 to $1,000	57	28	10	95
Group3 >$1,000 to $2,500	30	15	5	50
Group4 >$2,500	33	16	6	55
Grand Total	**156**	**75**	**27**	**258**

chi-test p-value	0.002478444

Cost Savings vs. Status w/o SBAG

SBAG Received (Multiple Items)

Observed

Count of Est. Cost Savings/year	Column Labels			
Row Labels	Implemented	Not Implemented	Partially Implemented	Grand Total
Group1 $0 to $200	17	22	7	46
Group2 >$200 to $1,000	18	34	9	61
Group3 >$1,000 to $2,500	13	8	3	24

Group4 >$2,500	14	7	3	24
Grand Total	62	71	22	155

Expected

Count of Est. Cost Savings/year	**Column Labels**			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Group1 $0 to $200	18	21	7	46
Group2 >$200 to $1,000	24	28	9	61
Group3 >$1,000 to $2,500	10	11	3	24
Group4 >$2,500	10	11	3	24
Grand Total	**62**	**71**	**22**	**155**

chi-test p-value	0.186885995

3.1.5 Project cost

The project cost field was blank in 124 records of which 3 were in SBAG received records. To reconcile to the 359 completion records (359 – 124 = 235) and the 104 SBAG received records (104-3= 101). Chi-squared test p-value for all records is .000006 and without the SBAG received records is .057031. Analyzing data from the IAC program, Anderson & Newell (2004) found that around 40% of the firms were more responsive to capital costs than to energy savings. Among the categories tested these p-values for both with and without SBAG are the lowest values and show the greatest likelihood of dependence between the cost category and the implementation status.

This completes the evidence showing all five categories tested for influence in the decision or not show a p-value < .05 when the grants are included and a p-value > .05 when the grants are excluded.

Table 5
Project Cost vs. Status

Observed

Count of Est. Project Cost	Column Labels			
Row Labels	Implemented	Not Implemented	Partially Implemented	Grand Total
Group1 $0-$500	23	24	8	55
Group2 >$500-$5,000	31	29	2	62
Group3 >$5,000-$15,000	52	13	6	71
Group4 >$15,000	39	4	4	47
Grand Total	145	70	20	235

Expected

Count of Est. Project Cost	**Column Labels**			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Group1 $0-$500	34	16	5	55
Group2 >$500-$5,000	38	18	5	62
Group3 >$5,000-$15,000	44	21	6	71
Group4 >$15,000	29	14	4	47
Grand Total	**145**	**70**	**20**	**235**

chi-test p-value	0.000006

Project Cost vs. Status w/o SBAG

SBAG Received (Multiple Items)

Observed

Count of Est. Project Cost	Column Labels			
Row Labels	Implemented	Not Implemented	Partially Implemented	Grand Total
Group1 $0-$500	18	24	8	50
Group2 >$500-$5,000	15	28		43
Group3 >$5,000-$15,000	8	10	5	23
Group4 >$15,000	12	4	2	18
Grand Total	53	66	15	134

Expected

Count of Est. Project Cost	**Column Labels**			
Row Labels	**Implemented**	**Not Implemented**	**Partially Implemented**	**Grand Total**
Group1 $0-$500	20	25	6	50
Group2 >$500-$5,000	17	21	5	43
Group3 >$5,000-$15,000	9	11	3	23
Group4 >$15,000	7	9	2	18
Grand Total	**53**	**66**	**15**	**134**

chi-test p-value	0.057030877

Profile of projects			
	Average Cost	Average Savings	Calculated payback
SBAG projects implemented	$12,067	$3,036	3.97
Other projects implemented or partially implemented	$13,554	$2,718	4.99
Other projects not implemented	$3,779	$1,403	2.69

The projects that were ***not*** implemented would have a better impact on profitability (lower payback period) than the other categories. This is the energy-efficiency paradox in action. The smaller projects were not implemented supporting the findings from the study from the University of Pittsburgh (Doctors et al., 1978) that one of the biggest obstacles is a perception that potential energy savings are not worth the effort.

3.2 Regression analysis.

It could be argued that there was an unintended bias in the way the numerical categories; payback period, cost savings, and project cost, were grouped. Therefore, to further test for possible relationships regression analysis was used. Since we have three numerical categories, these were separately tested in a regression analysis with the status category. Implemented and partially implemented we designated as “1” and not implemented as “0”. The detailed results of the regression analysis are in the Appendices I, II, and III. None of the results showed significance either with or without SBAG records. A summary of the results are below.

	Correlation Coefficient	Significant/ not significant
Payback vs. Status	0.00019	**NS**
Payback vs. Status w/o SBAG	0.02088	**NS**
Project Cost vs. Status	0.01323	**NS**
Project Cost vs. Status w/o SBAG	0.02538	**NS**
Savings vs. Status	0.01494	**NS**
Savings vs. Status w/o SBAG	0.01449	**NS**

IV Conclusions

The analysis of the data using chi-square testing and regression analysis supports the hypothesis: **Grant money to small businesses in Pennsylvania is the single biggest factor in the decision to implement energy efficiency projects.** The implication is that without a grant program fewer energy efficiency projects will be implemented.

Lack of capital and the perception that the potential energy savings are not worth it were found to be the biggest obstacles to energy efficiency investments from a survey of small businesses in western Pennsylvania in 1977 (Doctors, Fahey, & Paton, 1978). The grant money influence on project implementation and the non-implementation of many low-cost projects support these findings as still valid today.

The grant programs of the PADEP approve applications on a first-come, first-serve basis. This does not necessarily reward the best projects. The PADEP in their new SBEEG program has started to address the environment effectiveness by increasing the criteria for energy savings.

With the minimum for this grant at $1,000 in energy savings per year, 50% of grants given to EMAP clients under the SBAG program would no longer be eligible. However this does not address the profitability to the small business. Is the single criterion on energy savings and not profitability the right solution in the best interest of the taxpayers who need jobs? Small business is the job creating engine of the U.S. economy.

Projects consist of two factors energy savings and profitability. A four quadrant matrix can be developed for examination of projects. The median for the payback period was 4.0 years and the median for the energy savings was $ 768/year. The quadrants are: **A – high energy savings and low payback period; B – high energy savings and high payback period; C – low energy savings and low payback period; and D – low energy savings and high payback period**. This matrix would look like the following for all the projects for which a decision has been made and an energy savings value has been recorded. The payback period was calculated from the project cost and the annual energy savings. The payback period is a proxy for return on investment, the lower the payback period the more profitable and less risky the investment. Projects in the ‘A’ quadrant should receive the major focus followed by those in ‘B’ and ‘C’. ‘D’ project should not get resources or attention.

	B		A	
High	Avg. Savings	$3,262.00	Avg. Savings	$6,376.00
energy	Avg. Cost	$22,994.00	Avg. Cost	$9,243.00
savings	Total projects	63	Total projects	58
	Not Implemented	12	Not Implemented	14
$768/yr	Grants Rec'd	38	Grants Rec'd	28
	D		**C**	
	Avg. Savings	$313.00	Avg. Savings	$262.00
	Avg. Cost	$6,302.00	Avg. cost	$391.00
Low	Total projects	57	Total projects	60
energy	Not Implemented	22	Not Implemented	30
savings	Grants Rec'd	7	Grants Rec'd	29
	Long payback		**4.0 yrs.**	***Short payback***
	Low profits			**High profits**

V Recommendations

5.1 Research.

- Further study needs to be conducted to determine the optimum level of a grant program.
- Is a grant program more efficient and effective than a tax credit program?
- What are the transactional costs associated with various types of energy efficiency projects? Are these affecting some of the apparently profitable projects to be much less profitable than the simple payback shows?
- Do some types of energy efficient projects have other benefits associated with them besides energy cost savings? Might this influence decisions on implementation?

5.2 EMAP

- Capturing the reason for not implementation should be expanded.
    - Time – break into two categories
        - Too much time.
        - Too long a payback.
    - Money – break into two categories
        - Project costs too much.
        - Lack capital.
    - Other –
        - Potential savings not worth the effort.
        - Low priority.
        - Will wait until energy costs go higher.
- Emphasize A projects – payback of 4.0 or less and savings of $ 768/yr. or greater.
- Reduce the number of data fields for each project.

The author acknowledges with thanks Mike Murphy and Fred Barrett for their assistance with statistical analysis and Nancy Crickman, Lee Ann Briggs, and Jeremy Hancher for information regarding EMAP projects.

Appendix I

Payback vs. status

Regression Statistics	
Multiple R	0.01388419
R Square	0.00019277
Adjusted R Square	-0.004436
Standard Error	0.45952105
Observations	218

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.008794064	0.008794	0.041646528	0.838487185
Residual	216	45.61047199	0.21116		
Total	217	45.61926606			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%
Intercept	0.70592417	0.037015593	19.07099	3.38131E-48	0.632966159	0.7788822	0.63296616
1	-0.0006953	0.003406928	-0.204075	0.838487185	-0.007410348	0.0060198	-0.00741035

Payback vs. status w/o SBAG

Regression Statistics	
Multiple R	0.14451988
R Square	0.02088599
Adjusted R Square	0.01298991
Standard Error	0.49866208
Observations	126

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.657743062	0.657743	2.64510904	0.106407748
Residual	124	30.83432043	0.248664		
Total	125	31.49206349			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%
Intercept	0.56737817	0.057526632	9.862878	2.72082E-17	0.453516857	0.6812395	0.45351686
1	-0.0152952	0.009404435	-1.626379	0.106407748	-0.033909186	0.0033188	-0.03390919

Appendix II

Project cost vs. status

Regression Statistics	
Multiple R	0.11504151
R Square	0.013234549
Adjusted R Square	0.00898125
Standard Error	0.45679989
Observations	234

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.649284714	0.649285	3.111595949	0.07905285
Residual	232	48.41054435	0.208666		
Total	233	49.05982906			

		Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept		0.688072752	0.030728519	22.39199	6.56785E-60	0.627530137	0.74861537
	100	8.91712E-07	5.05514E-07	1.763972	0.07905285	-1.04272E-07	1.8877E-06

Cost vs. status w/o SBAG

Regression Statistics	
Multiple R	0.159303201
R Square	0.02537751
Adjusted R Square	0.017937644
Standard Error	0.497354573
Observations	133

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.843754501	0.843755	3.411016908	0.067018939
Residual	131	32.4043658	0.247362		
Total	132	33.2481203			

		Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept		0.487105113	0.044058778	11.0558	1.77074E-20	0.399946341	0.57426389
	100	1.02305E-06	5.53931E-07	1.846894	0.067018939	-7.27559E-08	2.1189E-06

Appendix III

Savings vs. status

Regression Statistics	
Multiple R	0.12223379
R Square	0.0149411
Adjusted R Square	0.01107812
Standard Error	0.45296096
Observations	257

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.793564274	0.793564	3.867769293	0.050306301
Residual	255	52.31927619	0.205174		
Total	256	53.11284047			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.68445015	0.030721693	22.27905	8.93179E-62	0.623949595	0.744950701
376	9.7377E-06	4.95138E-06	1.966665	0.050306301	-1.31014E-08	1.94885E-05

Savings vs. status w/o SBAG

Regression Statistics	
Multiple R	0.12038264
R Square	0.01449198
Adjusted R Square	0.00800837
Standard Error	0.49809955
Observations	154

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.554553455	0.554553	2.235172882	0.13697477
Residual	152	37.71168031	0.248103		
Total	153	38.26623377			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.51639522	0.042882152	12.04219	7.1137E-24	0.431673218	0.601117231
236	1.0667E-05	7.13474E-06	1.495049	0.13697477	-3.42927E-06	2.47629E-05

References

Anderson, S. T., & Newell, R. G. (2004). Information programs for technology adoption: The case of energy-efficiency audits. *Resource and Energy Economics, 26*(1), 27-50.

Bartos, F. J. (2005). Energy-efficient motors. *Control Engineering, 52*(7), 32-+.

Boslaugh, S., & Watters, P. A. (2008). *Statistics in a nutshell*. Sebastopol,CA: O'Reilly.

Boyd, G., Dutrow, E., & Tunnessen, W. (2008). The evolution of the ENERGY STAR (R) energy performance indicator for benchmarking industrial plant manufacturing energy use. *Journal of Cleaner Production, 16*(6), 709-715.

Decanio, S. J. (1993). BARRIERS WITHIN FIRMS TO ENERGY-EFFICIENT INVESTMENTS. *Energy Policy, 21*(9), 906-914.

DeCanio, S. J., & Watkins, W. E. (1998). Investment in energy efficiency: Do the characteristics of firms matter? *Review of Economics and Statistics, 80*(1), 95-107.

Doctors, S. I., Fahey, L., & Patton, G. R. (1978). The response of small manufacturers to the energy environment- an exploratory study. *American Journal of Small Business, 3*(2), 16-27.

Goitein, B. (1989). Organization decision-making and energy conservation investments. *Evaluation and Program Planning, 12*, 143-151.

Gowdy, J. M. (2007). Toward an experimental foundation for benefit-cost analysis. 649-655.

Howarth, R. B., Haddad, B. M., & Paton, B. (2000). The economics of energy efficiency: Insights from voluntary participation programs. *Energy Policy, 28*(6-7), 477-486.

Jaffe, A. B., & Stavins, R. N. (1994). The energy paradox and the diffusion of conservation technology. *Resource and Energy Economics, 16*(2), 91-122.

Levinson, A., & Niemann, S. (2004). Energy use by apartment tenants when landlords pay for utilities. *Resource and Energy Economics, 26*(1), 51-75.

Mims, N., Bell, M., & Doig, S. (2009). *Assessing the electric productivity gap and the U.S. efficiency opportunity*. Boulder, Colorado: Rocky Mountain Institute.

PADEP. (2008). *Small business advantage grant program.* Retrieved 2/10, 2009, from http:www.depweb.state.pa.us, keyword: SBAdvantage

PADEP. (2009). *Small business energy efficiency grant program.* Retrieved 2/10, 2009, from http:www.depweb.state.pa.us keyword: Small Business Energy Efficiency Grant

Pye, M., & McKane, A. (2000). Making a stronger case for industrial energy efficiency by quantifying non-energy benefits. *Resources Conservation and Recycling, 28*(3-4), 171-183.

Sanstad, A. H., & Howarth, R. B. (1994). NORMAL MARKETS, MARKET IMPERFECTIONS AND ENERGY EFFICIENCY. *Energy Policy, 22*(10), 811-818.

Schleich, J., & Gruber, E. (2008). Beyond case studies: Barriers to energy efficiency in commerce and the services sector. *Energy Economics, 30*(2), 449-464.

Stern, N. (2007). *The economics of climate change the stern review*. Cambridge: Cambridge University Press.

Tam, C. (2008). Developing indicators of energy efficiency. *Measuring sustainable production* (pp. 25) Interntional Energy Agency (IEA).

van Soest, D. P., & Bulte, E. H. (2001). Does the energy-efficiency paradox exist? technological progress and uncertainty. *Environmental & Resource Economics, 18*(1), 101-112.