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A Meta-Analysis of Energy Savings from Lighting Programs in Michigan

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A META-ANALYSIS OF ENERGY SAVINGS FROM LIGHTING PROGRAMS IN MICHIGAN

by

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In order to fill the gap in aggregates savings, the challenges faced by electric utilities for the demand of lighting energy are addressed by lighting efficiency programs. The shrinking capacity and electrical grid reliability call for improved ways to evaluate energy saving programs with evaluation methods that are robust in determining the impact of lighting programs. This study employed meta-analysis as an evaluation method to determine energy savings, impact, emissions of greenhouse gases (GHG), pollutants, and health effects from lighting programs in Michigan. The findings of the study showed the programs impact in Hedges' g of 0.36 for the overall programs. The four lighting programs differs in impacts with energy star program having the highest impact of 0.40, Residential lighting program 0.35, the commercial/Industrial for prescriptive-custom program and compact fluorescent-light emitting diode were 0.36 and 0.32 respectively. These programs were all cost effective as well as beneficial with respect to the investments. Other findings from the study include amount of avoided carbon dioxide, carbon dioxide equivalent, and avoided pollutants of nitrogen oxides and Sulphur dioxide responsible for health effects in Michigan. Energy savings improve air quality through

avoided particulate matter concentration that lead to avoided health effects that have economic value implications in Michigan. The study concludes that programs with more impact be given priority to gain on improved health and economic value.

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INTRODUCTION

According to a United States Environmental Protection Agency (EPA) report on efficient lighting, three out of four light sockets in the country contain inefficient light bulbs that consume approximately 200 billion KWh per year, producing over 140 million metric tons of carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions that keep the earth's atmosphere warmer than it should normally be (impact global temperature). In addition, the emission of pollutants impacts the quality of air that leads to negative health effects, and inefficient bulbs negatively impact disposable incomes (United States Environmental Protection Agency, 2011). Lighting systems have the largest estimated potential for energy savings than any other appliance (Williams, Atkinson, Garbesi, & Rubinstein, 2011). Lighting programs in general are designed by stratification of the random samples on the basis of residential, commercial (business) and industrial. The program activities include giving of a rebate – the instant discount given to residential customers' that apply for a variety of lighting equipment's and bulbs. The programs provide no-cost installation of efficient lighting equipment in living units and discount installations in common areas (interior and exterior spaces) of buildings. almost all the lighting programs by design have some of the following incentives and promotions on CFL, LED and fixtures, which include:

- product incentive (type of bulb) and promotions on CFL, LED, fixtures, and other lighting equipment

- promotions of programs by budgets into buckets of $50K, $1-$5 million and $5-$10 million
- promotion by type that include mail-in-rebate and buy-down-discount. The mail-in-rebate is a coupon, receipt or barcode a customer gets on purchase of lighting lamps or lighting equipment and turns in to receive a check for a particular amount. Manufacturer rebates sometimes are obtainable at a particular store.

In particular, programs such as residential compact fluorescent lamps (CFLs) and light-emitting diode (LED) bulbs were designed to offer property owners services that will reduce energy use in their living units. Typically, a crew of installers retrofit CFL and LED lamps at no cost to property owners. The program is specifically meant for families to directly install energy efficient lighting for lightings programs. There are variations in design of each of these programs with the same goal of saving energy. The commercial/industrial fluorescent and LED program is for small businesses that target small non-residential customers that do not get service from other energy efficiency programs. These are customers that lack financial and technical resources to take part in available energy efficiency programs. Another program is the energy star lighting program that provides incentives as well as marketing support to establish and develop market share for the usage of ENERGY STAR lighting products through retailer shops. The commercial/industrial prescriptive and custom program is for properties that are built strictly for multifamily rentals. The program offers incentives to property owners that purchase specific high energy efficiency electrical units to retrofit individual units and public places. Prescriptive and custom rebate application forms are usually completed to show for such projects completed (CE, 2010 & DTE 2015).

Table 1.1 below gives a brief summary of each of the programs target customers, the activity involved with the program and investment for the program (CE 2010 & DTE 2015).

Table 1.1

Program Description

Program	**Target**	**Method**	**Cost ($ Million)**	**Benefit ($ Million)**
CICFL_LED	Small Non-Residential Customers	Provide service & Technical Support	$567	$2,015
CIPrescript_Custom	Business-Multifamily Rents	Rebates for Efficient energy purchases & KWh saving	$449	$1,594
EnergyStar	Retailer Shops	Incentive & Marketing Support	$1,107	$3,931
ResCFL_LED	Residential-Owner (Family)	Free Retrofit of CFL & LED	$848	$3,011
Total			**$2,972**	**$10,550**

These programs have become a resource in the United States to help slow the rate of energy consumption through improvement in buildings, and other areas of energy-using products (Sachs, 2012). Residential Lighting efficiency relies on an improved quantification of energy saving. Researchers have carried out studies on lighting for more than 30 years with varied saving estimates and metrics on an annual basis. Despite the growing research on energy efficiency as a resource, there are no empirical data published integrating findings across studies on energy savings from lighting programs for an aggregate summary effect (impact) across ten years. The findings that vary across studies are rendered in different metrics (Kilowatt-hour, Kilowatt/dollar, Kilowatt per floor area, Kilowatt per population and Kilowatt per GDP among others) percentages on an annual basis, which provides results not easy to interpret. Meta-analysis techniques enable the pooling of findings across studies of varying statistical effect size to give a superior estimate of the program's effectiveness (Durlak &Lipsey, 1991; Lipsey &

Wilson, 2001; Borenstein, Hedges, Higgins, & Rothstein, 2009; and Cooper, Hedges, & Valentine, 2009). The goal of this research is to employ an evaluation method meta-analysis in determining the energy savings of the lighting programs as mentioned above from 2006 through 2015 for an effect size (impact) and compare the variation in impacts of the lighting programs associated with the investment of the programs, using the cost-effectiveness test to inform decision-making.

Meta-analysis as an evaluation method was used to determine energy savings (impact) of lighting programs mentioned above in Michigan. The findings were that the programs had impacts on energy savings, which improves air quality that leads to avoided GHG, pollutants, health effects, and saving of disposable income.

Energy and Energy Efficiency Defined

Energy is the ability to do work. Humanity exploits various forms of energy that include chemical energy in biomass, electrical energy from generators, batteries, alternators by movements of electrons in electric fields producing currents, thermal energy, a form of kinetic energy an object possesses because of its motion and potential energy, and a stored energy that can be retrieved (William, 2008 & Rigden, 1996). Thermal energy is generated due to movement of particles. The greater the movement of the particles, the more the intensity of the thermal energy that is referred to by people as heat. Heat, represented as Q (or q) in thermodynamics, is thermal energy transfer. Therefore, thermal energy and thermal energy transfer are a form of energy. The standard unit of energy is the Joule (J). Others are British thermal unit (BTU) and calorie. The

BTU is the amount of heat energy that will raise the temperature of one pound of water by one degree Fahrenheit, while calorie is the energy required to raise the temperature of 1gram of water 1 degree Celsius (William, 2008). Gasoline is the energy needed to run our cars, much like calories are the energy our human body requires to function. A calorie is about 4.1868 Joule. The rate at which energy is transferred from one form of energy to another is referred to as power. This is the quantity of energy that notifies us how much energy gets transferred per second from electric potential in a light bulb of household per month or by Michigan in a year. This energy, divided by the duration in which the transfer takes place (J/s), is referred to as the Watt. The Watt is equal to 1J/s (Lindenfeld & Brahmia, 2011).

When a light bulb is turned on, a 15-W light bulb uses energy at the rate of approximately 15W, or 15J in each second. In a period of I h, it uses (15J/s) (3600s) or 54000J, and this is what we pay for to the utilities, Consumers Energy, DTE and others. When you turned on a device that uses 1000W, or one Kilowatt-hour (KWh), the device will use (1KW) (1h) or one Kilowatt-hour of energy in 1 hour. The device usage will be equal to (1000W) (3600) or 3.6×10^{6} J of energy. Therefore, a Kilowatt of energy is equal to 1000W of energy.

Energy efficiency is proportion of energy that is used instead of been wasted during production or consumption of energy. Energy is used efficiently in lighting homes by using compact fluorescent lamps and lighting emitting diode lamps that consume less energy.

According to Gillingham et al. (2009), energy efficiency is the energy services produced per unit of energy input. Energy efficiency intention is to reduce energy required to deliver a service. Improvement in energy efficiency means to use less energy for the same level of service (Brown, 2014). An example would be switching away from an incandescent lamp to a compact fluorescent lamp that produces the same amount of light, but uses less energy, produces less heat, and lasts longer. Energy efficiency is measured as n = energy output / energy input. As the value n approaches unity, the more efficient the system. In the case of lighting, the amount of lighting put out per watt of power used, tells the efficiency of the bulb in use. The more lumens per watt of power the better. Lumens (luminous flux) is measure of the amount of light emitted per second by a light source. The higher the amount of lumens the brighter the light, which according to U.S. office of EERE on *lumens and the lighting facts label discussions*, lumens are to light as gallons are to milk and pounds to bananas. On the contrary, reducing the absolute level of energy required is the object of energy conservation, which occurs by giving up personal comfort and satisfaction. A consumer that takes cooler showers in summer by setting the thermostat higher at the expense of personal comfort simply conserves energy. However, when less energy per lumen of lighting consumed delivers a service, the object is energy efficiency. Another example includes the amount of heat removed from air per kilowatt-hour of energy input is the energy efficiency of an air conditioner (Gillingham, et al., 2009). Energy efficiency is the energy input or electricity input at a personal level. However, energy efficiency at the product level includes product characteristic, product cost, and other attributes. At the national and state level, energy efficiency of a category or of the whole economy is measured as Gross Domestic Product (GDP) per unit of energy consumed in its output to enable analyses of energy intensity determinant at both the state and national level. The concept of energy efficiency is often confused with energy conservation, which is defined as reduction in the absolute level of energy consumed (Gillingham, et al., 2009).

According to U.S. Energy Information Administration (EIA) Residential Energy Consumption Survey (2015), the state of Michigan is cooler than most states of the United States. Space heating in Michigan consumes about 55% of energy used in homes. This is a high figure when compared with the United States' average of 41% used for space heating. The state's large population, northern climate, and industrial sector keep consumption of energy relatively high. According to Governor Rick Snyder (State of Michigan, 2015), "Michiganders pay more than the national average for energy that powers, warms, and cools their homes right now. That needs to change" (p. 2).

In lighting systems, compact fluorescent lamps provide more light and use less energy than using incandescent lamps. In addition, a washing machine that is energy efficient provides the service, washing, while using less energy (Energy Efficiency and Renewable Energy). To improve on the gains of energy efficiency, the United States Department of Energy (DOE) has provided funding for energy efficiency through the State's Energy Programs (SEP) for over a decade (Alliance to Save Energy, 2013). The funds released through the American Reinvestment and Recovery Act (ARRA) influenced energy efficiency programs through expansion. The State Energy Office (SEO) under the MPSC, DTE Energy, Consumers Energy, and other utility stakeholders worked together to implement energy efficiency programs in Michigan. This study uses meta-analysis to integrate findings across programs for a summary effect size. Meta-analysis includes a survey of the evaluation reports on energy savings of four lighting programs in Michigan from 2006 through 2015 duration, translating the study outcome into a common metric, and analyzing and interpreting the relationship between program patterns and outcomes.

This study is able to provide information on the findings across studies to fill the gap in lighting efficiency by combining different energy savings estimates, which are provided separately annually to determine the effect (impact) of lighting programs to assist Michigan in meeting present and future energy needs. Energy efficiency has long been the focus of the interests to protect the environment via a reduction of greenhouse gas (GHG) emissions, an increase in the security of energy supply, and deferring the need for new power plants.

Background

Policy makers, utilities, and regulators have given lighting efficiency greater consideration and importance, as concerns about climate change and demand for electricity escalate at the risk of emissions, unsteady and increased cost of natural gas for power generation, and the cost of building new power plants. Advocates and policy makers maintain that reducing demand for energy can address all of these challenges. Utilities planned to reduce load growth of between 20% - 40% through energy efficiency initiatives (Berry, 2008; & Gillingham, Newell, & Palmer, 2009). Advocates and implementers surmise that electricity use could drop by 20% from projected levels by 2020 through the application of energy efficiency policies and programs.

According to ACEEE, worldwide about 3.5 billion people dwell in cities, and the United Nations predicts the figure will double by 2050 (Ribeiro, et al., 2015). The report maintained that two-thirds of global energy use and 80% of the United States' energy use occurs in cities. In addition, about 75% of greenhouse gas, responsible for global warming, generates in urban areas. This means cities' high share of energy use and greenhouse gas emissions need energy efficiency actions to address these challenges. ACEEE further maintains that energy efficiency is the least expensive, most available, and most under-utilized resource for community development (Ribeiro, et al., 2015).

Energy efficiency has long been the focus of the enthusiasm to protect the environment. Reduction of greenhouse gas (GHG) emissions resulting from fossil-based energy systems increases in the security of the energy supply, and deferring the need for new power plants. The consumption of fossil fuels causes harm to human health and climate change. In addition, a lack of accurate and reliable information causes consumers and firms not to undertake investment in energy efficiency (Allcott & Greenstone, 2012). Although government at the federal and state levels has made concerted efforts through policies and programs to promote energy efficiency, energy saving estimates (lighting systems) and the costs associated with the policies and programs remain in dispute. The argument is whether there is an energy efficiency gap, or investment inefficiencies, that utility and public benefit policy and programs could correct. Claims of energy savings from increases in efficiency originate from engineering analysis and observational studies that may have inherent biases. Further, even with the knowledge of cost savings, lighting efficiency investments have other unobserved costs and benefits that make them difficult to quantify. The evidence available suggests investment inefficiencies, which cause increases in energy use (Allcott & Greenstone, 2012). In addition, projected energy savings (engineering models) are about 2.5 times the actual saving estimates, and projected returns on investments are poor on a variety of metrics (Fowlie, Greenstone, & Wolfram, 2015). It is critical to develop credible evidence on the true actual savings, and investments in lighting efficiency in particular, and energy efficiency in general.

Countries have shifted focus from technologies and resources to provide kilowatt-hours, an attempt of the policy goal to deliver the needed energy for sustainable development. Appeals for policies to improve end-use lighting efficiency have gained momentum over several decades to enhance the reduction of energy waste. Lighting efficiency (energy efficiency) initiatives as a resource are fast, cheap, and clean to deploy for nutrition, mobility, and other services of convenience (Brown, 2014). Energy efficiency entails delivering a given service using less energy; for instance, using less energy per lumen of lighting compact fluorescent lights to an incandescent bulb. Energy efficiency uses an inverse measure, energy intensity, which is an imperfect metric that depends on the output measure. The output measures include gross domestic product (GDP), population, and building space in square foot or manufactured goods per dollar. The imperfections associated with lighting efficiency measures calls for a meta-analysis to aggregate the different measures into a common effect size for decision-making.

In 1980, energy efficiency researchers formed the ACEEE, following the 1973 oil embargo imposed that increased energy prices. This spurs the motivation to conserve energy and improve energy efficiency in the United States and around the World. ACEEE has the mission of advancing energy efficiency policies, programs, technological breakthroughs, investments opportunities, and energy-related behaviors to the end of achieving economic prosperity, ensuring security of energy, and reducing environmental impacts (Nadel, Elliott, & Langer, 2015). According to Nadel et al., 2015 from 1980 to

2014, United States energy consumption increased by about 26%, while the US Gross Domestic Product (GDP) moved up by 149%. The figures show a decline in energy intensity from 12.1 thousand British Thermal Units [(BTUs)1.277276 x 10^6 Joules] per dollar in 1980 to 6.1 [(BTUs) 6.43916 x 10^3 Joules] per dollar in 2014, a 50% change. ACEEE affirmed that energy efficiency initiatives cause the improvement for a savings of about 58 quadrillion BTUs [6.12248 x 10^{19} Joules], which brought savings to consumers and businesses of $800 billion in 2014, about $2500 per capital (Nadel, Elliott, & Neal, 2015). According to EIA 2011 Annual Energy Outlook, energy consumption will total 112 Quads (11200 x 10^{18} Joules) by 2050 to support economic activities (Laitner, 2012). Laitner et al. (2012) affirmed that energy supplies in the U.S. were no longer required because of the energy gains due to energy efficiency measures adopted since 1973-1974, during the oil embargo. Energy efficiency measurement as a resource has played a critical role in the development of the United States economy. The reaped benefits of energy efficiency include reduced energy bills, low cost of maintenance, quality of energy supply, and opportunities for employment to mitigation of greenhouse gas (GHG) emissions. Furthermore, increased funding by the DOE through the American Reinvestment and Recovery Act (ARRA) has influenced the energy efficiency program in terms of expansion. Simultaneously, the DOE put the Energy Efficiency Conservation Block Grant (EECBG) decision into effect that made available over five billion dollars of additional funding to state energy offices (SEOs) that manage the funds. The level of expectation from the state's energy offices includes the development, administration, and implementation of the varied policies and programs of energy efficiency in the states. Funding of energy efficiency programs from both the public and private sector of the economy will be on the increase for many decades to come. Evaluators have focused on the effectiveness of energy saving potentials and impacts as these programs become significant to policymakers and funders. The estimate on ratepayer-funded energy efficiency programs in the United States would increase from $3.1 billion quoted in 2008 to $7.5 billion and $12.4 billion by 2020 under the medium and high framework of the programs. The annual electric energy savings expected from the increased funding falls in the range of 0.58% - 0.93% in 2020, upward from 0.34% in 2008 of retail sales (Messenger, Bharvirkar, Golemboski, Goldman, & Schiller, 2010). The increase in energy efficiency funding calls for determining the aggregate savings of the lighting programs with respect to the investments in dollars relative to leading states in energy efficiency and the national standard.

In addition, the 2007 Energy Independence and Security Act (EISA) placed a demand of about 28% improvement in efficiency for most types of screw-based light bulbs starting from 2012 through 2014. Dimetrosky, Parkinson and Lies (2015) affirmed that EISA effect in 2012 has continued to record savings in efficient lighting despite the challenges associated with evaluating the efficiency lighting programs. EISA does not make the determination of baseline easy, because the baseline changes on a yearly basis and the requirements placed on manufacturers is not always feasible, because purchases are made based on what is available in the inventory at a particular time.

Energy Efficiency Policy and Program

The last five decades has witnessed concerted efforts to develop national energy policies within the executive arm of the United States government, with some of the policies meeting the envisaged challenges on energy. These efforts reflect the priorities of the administrative arms of government at various levels. Cabinet members appointed by successive American presidents were the overseers of energy policy before the creation of the Department of Energy (DOE) in 1977 to be responsible for energy policy (Alliance to Save Energy, 2013) Bipartisan Policy Center [BPC], 2012).

President Richard Nixon had launched Project Independence, and later established the Federal Energy Office in 1970 and 1973 respectively in response to the 1973 oil embargo. The president wanted to reduce the United States' dependence on foreign oil, a desire that has been the priorities of successive American presidents as well. The DOE organization Act of 1977 that mandated the DOE to develop a National Energy Plan every two years succeeded in establishing goals of reducing energy demand and oil imports to increase in energy generation and efficiency (BPC, 2012).

The National Energy Strategy under President George H.W. Bush, enacted energy legislation in 1990. The Energy Policy Act of 1992—which promoted energy efficiency; increased energy supplies; reduced greenhouse gas emissions; improved air quality; promoted use of renewable energy sources and production of alternative transportation fuels; created jobs and boosted economic growth among others—established a framework for energy efficiency policy. President Clinton's administration thrived on this framework established under the Energy Policy Act of 1992, with a focus on tackling climate change. The events of the blackouts in California and the attack of September 11, 2001 gave impetus to the George W. Bush administration to refocus on energy and security policy.

Finally, President Barack Obama's administration initiated the American Recovery and Reinvestment Act (ARRA) of 2009, aimed to promote clean energy and improved transportation, with a provision of more than $90 billion in tax credits and direct spending on programs.

Energy policy has been a top priority in all successive American presidents with emphasis on reduced energy demand in the entire Act enacted. The Energy Policy Act of 1992 and the Energy Policy Act of 2005 has enhanced the development and deployment of energy efficiency policy.

The energy efficiency initiatives in the United States starts with the attributes of the purpose or problem that needs attention for theory-based policy design. The purpose might be expansion of energy efficiency investments and practices (Brown, 2015). The theory-based policy design is usually interested in program logic, the why and how of the program to help quantify energy efficiency resources for system planning. National and state energy policies need systematic methods that would track and make adjustments on the policies and programs of energy efficiency for effectiveness in achieving energy savings. The foregoing discourse on national energy efficiency identifies certain pitfalls associated with previous national energy policies that include the setting of inconsistent goals that were not only unrealistic but also politically motivated. A meta-analysis of energy savings from lighting efficiency attempts to narrow the gap on underlying assumptions of programs that efficiency measures will lead to reduction in energy usage, a reduction that justifies the investments in energy efficiency initiatives.

Legislation on energy policy has been the primary focus of the congress, though sometimes developed at the White House (BPC, 2012). Energy-affiliated legislation includes the following:

- National Appliance Energy Conservation Act of 1977, Public Law 100-12, for the expansion of efficiency standards for household appliances. This was amended by the National Appliance Energy Conservation Act of 1987, Energy Policy Act of 1992 and National Policy Act of 2005

- Energy Policy and Conservation Act of 1975, public Law 94-163, for some enhanced incentives to produce more oil, Strategic Petroleum Reserve and Corporate Average Fuel Economy standard for vehicle fuel economy

- Department of Energy Organization Act of 1977, Public Law 95-91, created the Department of Energy

- National Energy Act of 1978, Public Law 95-617, generates energy –efficiency programs, incentives for tax, also disincentives for tax, programs for energy conservation, programs for alternative fuel and regulatory and market-based incentives, which includes: Power Plant and Industrial Fuel Use Act, Policies Act for Natural Gas and Public Utility Regulatory, and Energy Tax Act

- Energy Security Act of 1980, Public Law 96-294, created programs to generate synthetic fuels that include solar, wind, geothermal and ocean energy; fuels from biomass and alcohols

- Energy Policy Act of 1992, Public Law, programs to enhance energy efficiency and conservation of energy in buildings; measures to improve on clean and renewable energy
- Energy Policy Act of 2005, Public Law 109-58, initiated tax reduction for domestic energy production and efficiency; boost national energy efficiency standards; bonds holders of clean renewable energy given new credit and initiated reliability and Renewable Fuels standards that were mandatory
- Energy Independence and Security Act of 2007, Public Law, enacted measures to increase energy efficiency of products, buildings, vehicles and encourage research and employ greenhouse gas capture and storage recourse to enhancement of energy efficiency performance of the federal government
- American Recovery and Reinvestment Act of 2009, Public Law, 111-5, ensures energy Research and Development, renewable and electricity-transmission loan guarantees, Treasury cash-grant program.

The United States Energy Policy Act of 2005 and Energy Policy Act of 2009 enunciated above have boosted investments in energy efficiency as a resource for both the government and private sector (BPC, 2012; Gold, Furry, Nadel, Laitner & Elliot, 2009; Gold & Nadel, 2011).

Energy Efficiency Indicators

Energy efficiency as a resource should be harnessed with vigor to ensure prosperity and global competiveness of the United States economy (Hayes et al., 2013). According to an ACEEE white paper, the United States has made some progress considering the energy efficiency indicators, but a lot needs to be done when compared with some of the advanced world economy. The 15 indicators developed by ACEEE strengthens the level and progress of energy efficiency in the United States, which this research focuses on annual energy savings from electricity from 2006 through 2015. The indicators include the following:

i. *Electricity and Natural Gas Efficiency Program budgets* looked at 2012 budget across the states. The budget for electricity given as $5, 958 million, while that of gas as $1,373 million at 2012. This shows an increase of 4% when compared with 2011 spending.

ii. *Annual savings from Electricity and Natural Gas Efficiency Programs* considers the 2011 electric savings of 22,013 GWh (gigawatt-hour) and natural gas of 19,763 Million Therms (MMtherms) due to energy efficiency. This represents a 19% increase in energy savings compared to year 2010.

iii. *Energy productivity* measures the economic output in a country per unit of energy consumed. Domestic gross product generated by the United States per One Million British Thermal Units (MMBtu) of energy consumed in 2012 stood at $157, which shows an increase of 5%

compared to the 2011 figure. The higher the number as indicator the better the efficiency.

iv. *Mandatory Energy Efficiency Resource Standards (EERS)* looked at the energy efficiency saving goals of country or state, which the United States does not have a comparing case of making energy efficiency mandatory in all the states. States typically choose the type of energy policy they want to pursue.

v. *Greenhouse Gas Emissions* that are responsible for global warming. The gases hold heat due to the trapped and absorbed infrared radiation. Reduced energy usage leads to reduced emissions. The 15 tons per person carbon dioxide emissions by the United States in 2012, shows an improvement of 5% over 2011 emissions.

vi. *Energy Intensity in Residential Buildings*-The building and commercial sectors measures energy consumed by square foot of floor space. The energy consumption by residential building in 2012 stood at 105,000 Btu/ft^2, which is an improvement of 6% over 2011.

vii. *Energy Intensity in Commercial Building* - The commercial energy consumption in the United States stood at 214,000 Btu/ft^2, which is 3% improvement over 2011.

viii. *States with Updated Building Codes* - Buildings usually set minimum performance standards to help reduce energy waste. According to

ACEEE, 31 states in the United States have an update of both residential and commercial buildings.

ix. *Disclosure of Energy Use in Buildings* – Labels (ratings) are provided on energy consumption of buildings, and usage disclosure made public. The information is relevant for the energy efficiency value of the building during purchase or rent.

x. *Appliances and Equipment Performance Standards*-minimum performance standards of appliances and equipment are essential for a cumulative energy savings (quadrillion Btu) in a particular year. Energy savings to a value of 3.71 quads expected in 2012 to make a 5% improvement over 2011

xi. *Energy Intensity of the Industrial Sector* - This is a measure of the amount of energy used per dollar of goods shipped by the industrial sector. The industrial sector consumed 4.45 KBtu per dollar of goods shipped, an improvement from 2011 figure (Hayes, et al., 2013).

xii. *Combined Heat and Power in Industry* - a single integrated system is used to generate electricity as well as heat. This system is efficient in the generation of electricity and heat for industrial usage, rather than having separate units for electricity and heat generation.

xiii. *Energy Intensity of Freight Transport* - The distance travelled or covered by unit amount of energy is an indication of the efficiency of which goods move around the country. The United States moved 1.13 ton-miles per thousand of Btus in 2011 that showed an insignificant change in energy efficiency.

xiv. *Fuel Economy of Passenger Vehicles and Light Trucks* - How much fuel consumed to transport passengers is an indication of the energy efficiency of the vehicle. The average fuel economy as at 2012 is set at 23.8 miles per gallon, which is a slight change of less than 1% as at 2010.

xv. *Use of public transit* - The average number of people taking a trip on public transport is a measure of the efficiency of public transit vehicle. The number of trips per person in 2012 stood at 32, which did not change with 2011 statistics.

According to ACEEE, the United States needs to do more to stop waste of energy and improve on energy efficiency as a resource in all sectors. The United States came in ninth position out of the twelve largest world economies, and scored 47 points out of 100 possible points based on the above criteria (Hayes, et al., 2013). The foregoing is a reflection of the state of Michigan's situation on energy efficiency measures, which Michigan's energy efficiency situation is below the national average [Residential Energy Consumption (Survey),2015].

Energy Efficiency Program Evaluation

Evaluation is a core discipline that pervades all areas of human endeavor for maintenance and improvement (Stufflebeam & Coryn, 2014). An evaluation process gives attestation to measures such as efficiency, effectiveness, cost-effectiveness, validity, and reliability. In addition, evaluation makes assertions of accountability, accreditation, and worth and value of program interventions as a necessary service and guide to humanity. Evaluation provides a difference to the present program or improvements for future programs.

Energy efficiency program evaluation is essential to tracking energy savings that are difficult to measure (Kaufman & Palmer, 2010). Energy efficiency is a critical building block of state and national policies and programs to reduce energy consumption. The Public Act (PA 295) of 2008 placed a demand on program administrator to obtain an evaluation of the programs increase in energy savings with respect to the investment. Impact and process evaluation are the functions carried out by evaluators. The former assesses the energy savings achieved during the intervention to determine the cost-effectiveness of the program, while the latter seek to determine the activities that contribute to achieving the goal. If the activities lead to the goal, then may be termed as being of good quality or effective, and the best way to improve the program. Hence, evaluation refers to systematic determination of the merit or worth of a social program for the betterment of society, energy savings for instance to mitigate environmental effects. (Scriven, 1991 & Davidson, 2005).

Program evaluation involves organizing the activities into a relationship to achieve a desired objective efficiently. It is also a systematic assessment of activities directed toward particular goals (Stufflebeam & Coryn, 2014). Program evaluation finds its activities in utilities, services, and manufacturing companies, with such examples of energy efficiency programs in the states or country. Program evaluation is steered according to values and interests to solicit for judgment of importance or worth to give facts for decision-making about a program. The idea may be to address or support a program, whether to replicate or terminate the program, to request for accountability, or examine the source of the program. Program evaluation is also a process of trying out different approaches to improve provision of services or other professional endeavors. It is seen as a hypothetical discourse, a set of political or scientific concepts, and as a moral or social structure (Mathison, 2005). This gives perspective and credence of employing another research approach, meta-analysis, for lighting programs in Michigan.

Meta-analysis

Meta-analysis came into existence through concern to integrate through reasoning on the fragmented and disconnected or unclear data on educational research, scientific research, and evaluations. Gene V. Glass expresses discontent on the increasing data that cannot help in making inferences across the studies. He conceived the name *meta-analysis* during his presidential presentation in 1976 to the American Educational Research Association (Mathison, 2005). Meta-analysis is a type of organized and orderly evaluation tool used for collecting, analytically assessing, and synthesizing diverse individual studies (Goodman, Boyce, Sax, Beyer, & Prueitt, 2015). Meta-analysis uses quantitative methods to combine diverse data sets to address specific research questions to give an overall summary effect of the data set. In addition, Bamberger, Rugh, and Mabry (2012) defined meta-analysis thus: “Meta-analysis is the review and synthesis of all research or evaluation studies that have been conducted in a particular field” (p. 386). The authors added that meta-analysis is a useful tool for assessing validity threats by comparing the ratings for different evaluations to determine a consistent pattern of an attribute. The techniques used frequently in a meta-analysis are descriptive tables, graphical analyses, and statistical approach. Descriptive tables usually present the point estimate alongside standard error or confidence interval of each of the study outcomes, and a forest plot used for graphical presentations for ease of detecting and comparing patterns. The statistical approach offers weighting, using such standards as relative study size and variation among studies. The synthesized study results are accomplished by employing weighted results and meta-regression, which uses regression techniques for examining the effects of modifying factors on the results. Meta-analysis typically encompasses four phases that include: searching to select pertinent studies; coding the studies according to patterns; converting the outcome of the studies to common metric, then analyzing and interpreting the link or correlation between studies' patterns and outcomes. The responsibility of combining data from diverse studies before the 1990s rested on the narrative review. The limitation of the approach bordered on personal feelings, emotions, lack of transparency and less utility for a large data of information (Borenstein, et al., 2009). According to Borenstein et al. (2009), meta-analysis is the statistical synthesis of data for an effect to support a program and evidence-based policy or practice. The purpose is to think of the model used in analyzing the data, the sensitivity analysis employed, and the interpretation of the results. This depended on the purpose of the synthesis, along with available data. The study focuses on meta-analysis of effects size, and energy saving from lighting programs. Each program yields an estimate of some statistics, a standardized difference, mean difference, or a risk ratio. The goal is to assess the dispersions in the effects, and if suitable, compute summary effects that answers the research question (s) based on the available evidence to inform policy decision.

Statement of the Problem

Lighting systems across most sectors in the United States have become energy efficient over the last ten years. However, some sectors still use inefficient light bulbs that make savings and cost-effectiveness difficult to predict. Lighting systems that are energy efficient have a huge potential to reduce the United States' energy consumption (Williams, et al., 2012). Lighting efficiency relies on an improved quantification of energy saving. Researchers have carried out studies on lighting for more than 30 years with varied saving estimates and metrics on an annual basis. Despite the growing research on energy efficiency as a resource, there are no empirical data published integrating findings across studies on energy savings from lighting programs for an aggregate summary effect across ten years. The findings that vary across studies are rendered in different metrics on an annual basis, which provides results that are not easy to interpret. Meta-analysis techniques enable the pooling of findings across studies of varying statistical effect size to give a superior estimate of the program's effectiveness (Durlak &Lipsey, 1991; Lipsey & Wilson, 2001; Borenstein et al., 2009 and Cooper et al., 2009). The goal is to describe the distribution of the included programs on energy savings, including the mean savings, establishing the extent (confidence interval) of the savings around the mean savings, and determining the variation in savings from each of the programs to inform decision-making. The programs include energy savings from lighting programs in Michigan, such as residential compact fluorescent (CFLs) and light emitting diode (LED) bulbs, commercial/industrial fluorescent, and LED retrofit, EnergyStar rebate, and the commercial/industrial prescriptive and custom programs from years 2006 through 2015 for a summary effect size. The residential program with emphasis on lighting is a program that gives incentives to property owners for common interior and exterior areas to help reduce energy use; commercial/industrial CFL and LED retrofit promote energy saving opportunities to businesses through the installation of lighting options that are cost-effective to customers; the energy star program gives incentives as well as marketing support through retail stores to acquire market share and usage of lighting products and the commercial/industrial prescriptive; and custom program gives rebates of a certain amount for specific energy saving upgrades and rebates given for an amount of kilowatts of savings for prescriptive and custom programs (CE, 2014). Therefore, policy makers and program administrators' decisions will be enhanced regarding whether to give a particular program more funding, continue with the program, or discontinue the program based on the findings and interpretations. In addition, the cost-effectiveness of lighting programs will be determined for the effective use of scarce resources taken by the programs. Cost-effectiveness is a measure that compares the relative benefits to the cost in the context of energy efficiency programs, which is the comparison of the benefits of lighting efficiency with the costs. Following the commencement of ratepayer-funded energy efficiency programs, it became imperative to employ cost-effectiveness tests to ensure that funds used for the program are beneficial to utilities and consumers.

Cost-effectiveness analysis is a substitute to cost-benefit analysis, which makes a comparison of the relative costs to the outcomes of investing in energy efficiency. cost-effectiveness analysis becomes useful when constraints are faced to monetize benefits, for example, the difficulty in putting monetary value on outcomes (avoided pollutants or health effects), but the number of lives saved as result of the avoided health issue can be counted. It is easy to measure the cost of investment in dollar value, and the effectiveness of how many lives are saved, but the two cannot be computed through addition or subtraction to obtain a single criterion of measure. One can compute the effectiveness per unit of cost (lives that are saved per dollar spent) in energy efficiency investment (Tan-Torres Edejer, Baltussen, Hutubessy, Acharya, Evans & Murray, 2003). According to Tan-Torres et al. (2003), cost-benefit includes converting all the benefits and costs into monetary terms. These include environmental, social benefits, and impacts associated with energy efficiency investments and the resultant outcome. However, other intangible benefits are difficult to estimate in monetary or physical terms, and such benefits include avoided health effects leading to avoided mortality rates due to energy savings from lighting. Cost-effectiveness identifies the most cost effective alternative of meeting investment goals with the available resources. The difference between cost-effectiveness and cost-benefit is that the latter has costs and benefits expressed in monetary units, while the former measures in units or social benefits that may be difficult to quantify. Now, cost-effectiveness is the achievement of a goal at a lower cost compared with the alternatives available, which might not be the least cost alternative or method of achievement, whereas cost-efficiency is the maximum achievement of the goal (outcome or impact) with the least amount of resources (input) available. Efficiency in energy savings relates the impact of a program to its costs by monetizing the benefits obtained from program activities, which becomes difficult in estimating and monetizing the outputs and outcomes. Thus, an assessment of efficiency focuses on the number of lives saved and the household that benefited from the energy savings per amount of dollars invested.

According to the National Action Plan for Energy Efficiency (NAPEE), there are five cost-effectiveness tests that have been used for over 20 years as the approaches for energy efficiency program evaluation. These include participant cost test (PCT), the utility system resource cost test (USRCT) or program administrator cost test (PACT), the ratepayer impact measure test (RIM), the total resource cost test (TRC), and the societal cost test (SCT). The five tests are described below. The tests used most often across the country for the determination of cost-effectiveness of energy efficiency programs include the TRC, PACT, and SCT. However, each of the tests proffer varied information about the impact of the energy efficiency (lighting efficiency) programs from different perspectives in the energy-efficiency system, and none of the cost-effectiveness tests are the best, though multiple tests provide an all-inclusive approach for answering questions on the overall effectiveness of the program, whether the program is balanced in terms of having some costs incentives too high or too low, and the adjustments needed to improve the program (NAPEE, 2008).

The basics of calculating each cost-effectiveness test in dollar terms is to determine whether the overall costs are below the overall benefits. A benefit-to-cost ratio greater than one indicate that the program has positive net benefits, and less than one indicates the costs exceed the benefits. Another method involves finding the difference of the net-present-value (NPV) dollars of the benefits and the costs. A good test should indicate a positive value of the difference. The two methods for the test are shown below (NAPEE, 2008).

Benefit-Cost Ratio = NPV ∑ benefits (dollars) / NPV ∑ costs (dollars)

Net Benefits (dollars) = NPV ∑benefits (dollars) – NPV ∑ costs (dollars)

I. PCT – This includes the costs and benefits experienced by the customer in the program. The direct expenses incurred for the purchase, installation, and operation of efficiency measures are costs. The reduction in energy bills and financial incentive received by the customer are the benefits. This is calculated as participant benefits / participant costs.

II. USRCT or PACT – This includes all the costs and benefits experienced by the utility or program administrator. It includes all costs incurred to design, plan, administer, and implement the efficiency programs, and all the benefits related with generations, transmission, and distribution. This is calculated as avoided cost benefits / program costs. The avoided costs as applied to all the tests include the cost of building a power plant, transmission, and distribution. Other avoided costs include reduction and removal of emissions.

III. RIM – The test gives an indication of the impact of the efficiency programs on utility rates. The results of the test give an indication of the impact of the program to customers that do not participate in the efficiency programs. The program administrators' expenditures and lost revenue due to low sales are the cost, while the benefits include avoided costs by the utility. This is calculated as avoided cost benefits/ program costs and lost revenues.

IV. TRC – This includes all the costs and benefits experienced by the program administrator and the program participants. It has the advantage of including all the incremental costs of the efficiency measure, and benefits such as avoided water costs, decrease operation and maintenance costs, enhanced comfort level, and improved health and safety. This is calculated as avoided costs benefits/program and participant costs.

V. SCT – This includes all impacts experienced by all members of society. It encompasses all the costs and benefits of the TRC test, and the impacts, such as externalities-environmental costs and reduced costs for government services. This is calculated as avoided cost and society benefits/program and participant costs.

Energy efficiency has long been the focus of the enthusiasm to protect the environment. Reduction of greenhouse gas (GHG) emissions resulting from fossil-based energy systems, increases in the security of the energy supply, and deferring the need for new power plants all translate to increased energy efficiency. The consumption of fossil fuels causes harm to human health and the climate. In addition, a lack of accurate and reliable information causes consumers and firms not to undertake investment in energy efficiency (Allcott & Greenstone, 2012). Consequently, Congress moved to pass the bi-partisan Energy Independence and Security Act (EISA) of 2007, which included elevated energy-efficiency standards for light bulbs to leverage new lighting technologies to reduce energy bills and increase energy security. The 2007 Act requires an elevated efficiency of at least 27% more than the traditional incandescent lamp. Improved lighting technologies include compact fluorescent lamps (CFLs) and light emitting diodes (LEDs), which use less energy with longer hours of operations than the traditional incandescent bulbs. According to the Environmental Protection Agency (EPA) report on next-generation lighting programs, three out of four power outlets (light sockets) contain light bulbs that are not efficient. The energy consumption of the inefficient light bulb is about 200 billion KWh per year, which results in over 140 million metric tons of carbon dioxide (CO_2) emissions (U.S.EPA, 2011). Programs that promote efficient lighting bulbs have made decisive steps; cost effective savings from efficient bulbs have been huge over the years in reducing energy use and maintenance cost of residential, government, and commercial/industrial buildings. Although government at the federal and state levels has enacted legislation through policies and programs to promote energy efficiency, energy saving estimates and the costs associated with the policies and programs remain in dispute. The argument is whether there is an energy efficiency gap or investment inefficiencies that utility lighting programs could correct. Claims of energy savings from increases in efficiency originate from engineering analysis and observational studies that may have inherent biases. Further, even with the knowledge of cost savings, energy efficiency investments have other unobserved costs and benefits that make them difficult to assess.

Michigan has made concerted efforts in the evaluation of energy efficiency policies and programs. Michigan's total energy consumption remains relatively high. According to the Michigan Public Service Commission (MPSC, 2011), Michigan gets about 97% of its petroleum from outside the state. In addition, natural gas, coal, and nuclear fuel for power generation comes from other states and nations. Michigan spent

$31.3 billion on all forms of energy as of year 2009, and, of that amount, $22.6 billion accounts for imports from other states. Michigan's energy profile in 2014, as updated in early 2015, indicates that 50% of net electricity generation comes from coal imported from the states of Wyoming and Montana (U. S. Energy Information Administration, 2015). Energy efficiency is a huge resource that offers states a cost-effective approach for meeting energy needs with reduced consumption and mitigation of greenhouse gas emissions (Gillingham et al., 2009). In addition, Michigan's inhabitants and businesses expressed concern regarding the out-of-state import of energy for access to energy supply, consumption, and expenditure of about 72% of every dollar circulating in the Michigan economy (MPSC, 2011). Michigan investments in energy efficiency policies and programs includes offering loans, rebates, and some forms of incentives in the agricultural sector. Businesses in Michigan independently owned with about 500 employees in full-time employment have access to loans of up to $400,000 with a low interest rate in the neighborhood of 5% or lower. The small businesses loan program (P2 loan program) funds only projects that would either eliminate waste or reduce waste on specific projects sites. This entails reuse or recycling in order to reduce on energy consumption and water waste for reduced environmental impact (ACEEE, 2015). Department of Management and Budget (DMB) in collaboration with the State energy office (Michigan Agency for Energy) has a mandate of reducing 25% of government public building grid-energy purchased by 2015, based on a 2002 energy purchase baseline. In addition, all government buildings are required to comply with the Energy Star Portfolio Manager tool in all the estimated 1100 buildings marked for the program. Other ambitious policy and programs by the state include the Energy Savings

Performance Contracting, Research, and Development in the area of energy efficiency and battery storage. Energy efficiency standards have been established by the United States EPA since June, 2014. The EPA proposed a 32% reduction of carbon dioxide emission by 2030 from electric generating units (EGUs). The Clean Power Plan (CPP) comes into effect by 2016 with a submission of carbon-cutting plans (U.S.EPA, 2015 & Hibbard, Franklin, & Okie, 2014).

Purpose of the Study

The purpose of this study is to assess actual energy savings for lighting programs in Michigan, and to determine the impact of energy savings from lighting and its cost-effectiveness. In addition, determine total greenhouse gas (GHG) emissions reduction from the lighting programs and the program with the most emission reduction. This is necessary in order to decide on a program's plan and design, which serves as a guide to program implementers for ensuring transparency and accountability in energy savings and disbursement of funds. Program implementers of energy efficiency measures calculate energy savings as a function of the product of number of units of efficiency measure installed and presumed energy savings per unit of energy efficient CFLs bulb installed (Kaufman & Palmer, 2010). This approach does not encompass energy-related behavior and other variables to give a precise measure of energy savings. It is imperative to access data of actual energy usage as monitored to answer the counterfactual question on the level of energy consumption in the absence of energy efficiency policies and programs.

This study conducts a meta-analysis of energy savings from lighting programs with the aim of aggregating and assessing the overall result of the program activities, and the extent to which the program worked or did not work to justify the expenses associated with the program.

Research Questions

1. In Michigan from 2006 – 2015, using meta-analysis, what is the impact of programs to create energy savings in lighting, and which programs are the most cost effective with respect to the investment?
2. What is the total GHG emissions reduction from the energy efficient lighting? Which lighting efficiency program or activity gives the most GHG emissions reduction?

Rationale and Theoretical Framework

This study was conducted to fill the gap in the research on aggregate energy savings from lighting programs and policies in Michigan. The majority of the existing research in this area is survey-based and on the activities of lighting programs (lighting efficiency) carried out in the state. This study focuses on actual implementation data of the lighting programs, with a view of comparing the study's conclusions on energy savings in KWh relative to the investments in dollars, and the overall impact of the resultant energy saved in Michigan. Energy efficiency is a relatively new field as a resource for energy demand and security in comparison to other areas. There is no empirical data published that integrates findings on energy savings of lighting programs from 2006 through 2015 in Michigan by researchers and evaluators using a statistical technique, such as meta-analysis.

The theoretical basis or framework for the study is the understanding that government and organizations often have diverse goals on energy utilization that need to be aligned. Energy efficiency as a resource supports the alignment of the reduction of energy usage and mitigation of greenhouse gas (GHG) emissions by utilizing goal-framing theory. According to Lindenberg and Steg (2013), “Goal-framing theory deals with the power of goals to govern cognitive and motivational processes, and focuses on the overarching goals: hedonic, gain, and normative goals” (p.49). When human behavior results in not acting pro-environmentally, it is referred to as gain and hedonic goal frames in the environmental context. Behavioral manners that are pro-environmental are normative goal frames. The lifestyle of comfort secured, and the decision to improve on energy usage is a hedonic goal, while the decision to invest in energy efficiency for the future is a gain goal. The overarching normative goal focuses on what is right and beneficial to the community. This is about getting people involved in energy efficiency activities that are beneficial to the community in comparison to non-involvement that is less beneficial. The assumption that lighting efficiency (energy efficiency) is a resource that leads to reductions in energy use, and community stands to benefit with participation is strengthened. This concept that lighting efficiency is a preferred resource has influenced utilities and regulatory bodies for 30 years (Geller, Howard, Harrington, Rosenfield, Tanishima, Satoshi & Unander, et al., 2006).

Significance of the Study

This study is able to provide information on the findings in the context of other studies on the impact of lighting programs in Michigan. The significance of the study is to fill a crucial gap in knowledge about the impact of energy-efficient lighting programs, particularly aggregate energy savings, to assist Michigan in meeting present and future energy needs. The study employs the method of meta-analysis to determine the overall and make comparisons of energy savings across the lighting programs and the costs associated with the programs over time in Michigan. The assumption is that compiling the results of existing evaluations of individual lighting programs through formal meta-analysis will yield more robust findings on energy savings and cost-effectiveness, thus overcoming the limitations of separate evaluations of numerous lighting programs which sometimes report contradictory results (Durlak &Lipsey, 1991; Lipsey & Wilson, 2001; Borenstein et al., 2009 and Cooper et al., 2009; Stufflebeam & Coryn, 2014).

The study is important because energy efficiency and reduced energy consumption have been a global concern for the past 30 years. Energy efficiency improvements led to savings of 48.2 Exajoule [EJ (48.2 * 10^{18} Joule)], which is about 13388888888889 KWh in nations belonging to the Organization for Economic Cooperation and Development (OECD), finding that without the improvements, 49% more energy would have been consumed in 1973 than in 1998 (Geller, et al., 2006**)**. In addition, Michigan households and industries will save money from avoiding the waste of energy from inefficient lighting, money that could be invested in other needs that will improve the Michigan economy.

Synopsis of the Study

This study includes Chapters One discussed, Two, Three, Four and Five to be discussed. Chapter One introduced the concept of energy efficiency; defined the terms energy and energy efficiency with examples for clarity, and gives a perspective on energy efficiency policies and programs. The chapter also explains energy-efficiency program evaluation, introduces meta-analysis as one of the approaches of evaluation for quasi-evaluations studies, states statement of the problem, provides a purpose of the study, and introduces the research questions, rationale, and theoretical framework for the study and the significance of the study.

Chapter Two gives a brief background and history of energy efficiency and its impacts by both state and federal policies. The chapter gives perspective on lighting programs in Michigan, and ends with a consideration of meta-analysis, an evaluation method to be used for the study synthesis and analysis.

Chapter Three focuses on the methodological aspect of the study that includes problem formulation, a literature search, data evaluation, data analysis, interpretation of results, and public presentation.

Chapter Four gives the result of the findings, and the overall impact and individual impacts of the lighting program in Michigan. The chapter mentions the extent of the robustness of the data using sensitivity analysis as an exploratory method. A comparison of the programs form part of the findings and the quantity of avoided greenhouse gases and pollutants that leads to health effects. The quantity of total energy saved used to calculate the emissions.

Chapter Five concludes with revisiting the research questions to proffer answers on the findings. The chapter discusses the synthesis and the limitations of the data based on studies available. The chapter ends with a contribution of the research to the field of evaluation, and makes a number of recommendations on further research and program considerations.

CHAPTER II

LITERATURE REVIEW

The review gives a brief background of the study, looks at the history with regard to research trends relevant to the study, identifies the gap needed to fill, and situates the study within a particular methodology that encompasses so many disciplines of research. The component areas of the studies that constitute the literature review include:

i. Energy Efficiency: A Brief Background and History

ii. The Impact of Energy Efficiency by Federal Policies

iii. State Energy Efficiency Policies and Programs

iv. Lighting Programs in Michigan

v. Meta-analysis of Energy savings from Lighting Programs

Energy Efficiency: A Brief Background and History

The energy problem of the 1970s vis-a-vis the oil embargo of 1973 ushered in a period of volatile energy supplies associated with other factors that culminated in high inflation in the United States. The energy efficiency improvements recorded following the oil embargo in the United States affected the gross domestic product (GDP) positively with increase in energy productivity in the neighborhood of 75% relative to 1970. The economic change did influence changes in energy consumption in buildings, transportation, and industrial sectors. Residential and commercial buildings energy consumption stand at 41% today, a decline from 48% between 1980 and 2009 statistics. However, the decline in energy consumption has been slow with less impact, but due to the adoption of appliance efficiency standards, and the utilities and government supported demand-side management (DSM) programs, decline in energy consumption is expected to be faster (Alliance to Save Energy, 2013). The energy usage in the transportation sector rose briefly, and then declined during the economic recessions. The zoning laws in the United States influence the spread in development and land-use patterns, which improved vehicle miles travelled (VMT) between 1991 to 2004 by a growth of 38.4%, which suppressed a rise in energy consumption due to the Corporate Average Fuel Economy (CAFÉ) standard adopted in 1975 that lack policies at both the national and state level. The industrial sector witnessed a period of decline in energy use, the move from energy-intensive manufacturing (iron, aluminum, steel) into services and information technology. The increase in industrial sector Gross Domestic Product (GDP) by 60% with a corresponding rise in energy use of only 12% between 1985 and 2003 accounts for the shift in manufacturing (Alliance to Save, Energy, 2013 & Interlaboratory Working Group, 2000).

Following the shift in manufacturing, policy makers, utilities, and regulators have given energy efficiency greater consideration and importance, as concerns about climate change and the demand for electricity escalate. Advocates and policy makers maintain that reducing demand for energy will mitigate all these challenges (Gillingham, Newell & Palmer, 2004 & Interlaboratory Working Group, 2000). Lighting accounts for a huge share of global energy consumption that is emitted as heat from inefficient bulbs. Many utilities have achieved much of their energy and demand savings through lighting programs. However, the use of inefficient incandescent lighting in some sectors, residential for example, shows a low efficient use of energy (Lee, Park, & Han, 2013). Consequently, Congress moved to pass the bi-partisan Energy Independence and Security Act (EISA) of 2007, which included elevated energy-efficiency standards for light bulbs to leverage new lighting technologies, reduce energy bills and increase energy security. The 2007 Act requires an elevated efficiency of at least 27% more than the traditional incandescent lamp. Improved lighting technologies include compact fluorescent lamps (CFLs) and light emitting diodes (LEDs), which use less energy with longer hours of operations than the traditional incandescent bulbs.

States have enacted legislation that offers incentives to residential, government, and commercial/industrial consumers interested in energy-efficient technologies [National Conference of State Legislatures (NCSL), 2015]. Programs created by states both educate and finance the up-front costs to upgrade the customers' old lighting system. These programs, which include halogen incandescent, compact fluorescent, and LED lighting, all of which presently save energy up to 75% compared to traditional incandescent, which loses 90% of the energy used by the bulb as heat. Energy-saving incandescent bulbs use 27% less energy as compared to traditional incandescent, and compact fluorescent lamps (CFLs) uses less energy, saving up to 75% as compared to incandescent. These lighting efficiency programs by the federal government became an incentive for other states interested in energy savings programs to adopt.

Michigan created the Energy Optimization (EO) standard, under public Act 295 of 2008 (PA 295 or Act) and signed into law October, 2008. The Act entails a reduction in energy usage from all utility providers in the state (Quackenbush, Talbers, & Saari, 2015). Michigan utilities commenced offering the energy efficiency upstream lighting program in 2009, following the establishment of the Act.

According to EIA Residential Energy Consumption Survey (2015), Michigan is cooler than most states of the United States. Space heating in Michigan consumes about 55% of energy used in homes. This is a high figure when compared with the United States' average of 41% used for space heating. The state's large population, northern climate, and industrial sector keep consumption of energy relatively high. According to Governor Rick Snyder (State of Michigan, 2015), "Michiganders pay more than the national average for energy that powers, warms, and cools their homes right now. That needs to change" (p. 2). The governor of Michigan calls for the elimination of energy waste in homes and businesses of Michigan residents.

The Impact of Energy Efficiency by Federal Policy

Following the presidency of Jimmy Carter in 1977, the formation of Department of Energy (DOE) became necessary in response to the emerging energy predicament, and the need to merge energy planning. The Department of Energy merged the following departments with other programs for an all-inclusive national energy plan. These include the Federal Energy Administration; the Federal Commission; the Energy Research and Development Administration and other government programs. This was strengthened by the American Congress, with the approval of the National Energy Act (NEA) in 1978 that included the National Energy Conservation Policy Act (NECPA), the Public Utility Regulatory Policies Act (PURPA), and the Power Plant and Industrial Fuel Act (PIFUA). According to the Alliance Commission on National Energy Efficiency (Alliance to Save

Energy, 2013), NECTA had demanded an establishment of energy efficiency standards for specified household appliances and products, which the DOE could not implement under NECTA. However, the Appliance Energy Conservation Act (NAECA) of 1987 established the first national home appliance standards by amending NECTA. As the energy prices stabilized, national appeal to energy policy diminished, and congress decided to enact the Energy Policy Act of 1992 (EPAct 1992) and signed into law important energy efficiency provisions. Another important energy legislation was the Energy Policy Act of 2005 (EPAct 2005), which provides for appliances standards, new tax incentives, and federal energy management enhancement. The estimated reduction in energy in 2010 by EPAct of 2005 stood at 0.66 Q [quad ($0.66 * 10^{18}$ Joules)] that represents 0.7% of total energy consumed in the year. In addition, an increase in energy savings has been projected to be 2.4 Q by 2020, which represents 2.3% of total expected energy usage (Alliance to Save Energy, 2013).

Another milestone for energy usage came two years after the EPAct 2005, which was the Energy Independence and Security Act (EISA) of 2007 mentioned above. The act underscored the precedence set for energy efficiency on energy use, and provides for a raise in corporate fuel-economy standards, strengthened appliance and equipment standards, new bulb efficiency standards, industrial efficiency programs, and several other energy strategies. According to Alliance to Alliance to Save Energy (2013), EISA would reduce energy usage up to 7% by 2030, saving American consumers and businesses more than $400 billion in avoided energy cost. The most recent law enacted to promote energy efficiency was the American Recovery and Reinvestment ACT (ARRA) of 2009, expected to restore the economy during the recession. In addition, ARRA allocated more than $25 billion for core energy efficiency, the largest single investment in energy efficiency in the United States. The core energy-efficiency programs include the appliance rebate program, energy efficiency and conservation, block grant program, state energy programs, weatherization assistance program, federal high performance green buildings, tax incentives, and Smart Grid grants.

Notwithstanding the improvements made so far on energy usage, there exist great prospects in pursuing energy efficiency policies and programs in every state of the United States. The differences in climate zones, formation, and characteristics of the economies of each state demand the adoption of unique energy efficiency policies and programs, especially states with high-level energy use per square foot of floor space, per unit of economic product, per capita or alternative measures of energy intensity.

State Energy Efficiency Policies and Programs

The State Energy Program (SEP) was created in 1970 through the reinforcement of the State Energy Conservation Program (SECP) and the Institutional Conservation Program (ICP). The programs became effective in 1975, where SECP provides funds for energy efficiency and renewable energy projects, ICP provides technical analysis of buildings on potentials energy savings for hospitals and schools. According to the Office of Energy Efficiency and Renewable Energy (2010), the framework of SEP went through a number of legislations that include the following:

- The Energy Policy and Conservation Act of 1975 (P.L. 94-163) set programs to encourage conservation of energy in federal buildings, industries and the State Energy Conservation Program.

- The Energy Conservation and Production Act of 1976 (P.L. 94-385) provided incentives through loans for conservation and renewable energy to enhanced the Energy Policy and Conservation Act of 1975.
- The Warner Amendment of 1983 (P.L. 95-105) apportion the Petroleum Violation Escrow Funds (overcharge for oil) to state energy programs. By 1986, Exxon and Stripper Well settlements added more than $4 billion to the funds.
- The State Energy Efficiency Programs Improvement Act of 1990 (P. L. 101-440) inspire states to designed activities that will improve energy efficiency and motivate investments in energy technology.
- The Energy Policy Act (EPAct) of 1992 (P. L. 102-486) authorized the DOE to fund revolving funds for energy efficiency development in state and local government buildings. The policy did extend to 2000 to boast the state's efforts in promoting energy efficiency technologies.

SEP received an allocation of more than $3.1 billion for formula grants under ARRA that were distributed in varied energy efficiency programs across the states. According to Alliance to Save Energy, every dollar of investment yields a savings of the DOE's SEP of $7.23 on energy bills (Alliance to Save Energy, 2013). In addition, states reveal that each $1 of federal investment in SEP attracts $10 of nonfederal investments in energy venture. SEP leads in maximizing the benefits associated with energy efficiency and renewable energy in states and local governments, through development of energy plans to improve on energy security. The goals include increasing energy efficiency initiatives in the United States economy; reduction on the cost of energy consumption; ensuring the reliability of electricity, fuel, and delivery of energy; deployment of alternative forms of energy and renewable energy resources; ensuring generation and usage of energy resources that reduces environmental emissions, and mitigating the reliance on imported oil.

The last several years have yielded the adoption of varied policies by the federal, states and local government aimed to increase energy efficiency. The logic and policy instruments differ in time and context, but have some themes that are common across the domains. These include the use of government policy to reduce and stabilize cost, strengthen energy security and reliability, and reduce environmental impact and energy-related expenses (Alliance to Save Energy, 2013). Federal government energy efficiency policies' focus has been on product standards and fiscal tools that influence the efficiency profile of products and investments. States focus on energy efficiency policies peculiar to their energy need and context, which includes the programs embarked upon by the utilities within their jurisdiction, such as individual states land-use planning tools; energy efficiency in building codes; and support for public transit to reduce on miles travelled and states tax incentives.

In 2014, the United States DOE invested more than $10 million in efficient lighting for research and development projects. The projects were expected to help move the development of high-quality LED, and organic light-emitting diode (OLED) that is cost-effective (U.S. EERE, 2014). In addition, the federal government in 2015 made another investment of more than $10 million in efficient lighting to support solid-state lighting (SSL) core technology research, product development, and manufacturing research and development, as well as build on the commitments to the global lighting challenge for clean energy (U.S. EERE, 2015).

Lighting Programs in Michigan

The United States DOE 2010 report on lighting market characteristics put the annual electricity consumption by lighting programs in the U.S. at 7000TWh [terawatt hours ($7000 * 10^{12}$ Watt-hours)]. The residential sector consumed 175TWh, the commercial sector consumed 349TWh, the industrial sector consumed 58TWh, and outdoor consumption stood at 118TWh, which is about 19% of total U.S. electricity use (U.S. DOE, 2012). According to the United States Energy Information Administration 2014 estimates of energy usage for lighting, 410 billion kilowatt-hours of electricity were consumed for lighting by the residential and commercial sector in the United States. Residential and commercial sectors consumed 150 billion KWh and 262 KWh respectively (EIA, 2015). This shows a decrease of 25 billion KWh and 127 billion KWh of electricity consumption by the residential and commercial sectors respectively, an indication of the impact energy efficiency measures undertaken at all levels of government.

In 2009, Michigan Energy Measure database (MEMD) was established, it was design to provide accurate information on energy savings in relation with technologies, and energy efficiency programs in the state. MEMD is updated on a monthly basis to help prioritize allocation of funds to efficiency measures. Consequently, Michigan Agency for Energy deploys SEP funds to boost energy efficiency and renewable energy resource to Michigan residents and businesses. The agency is a DOE-assigned state energy office, which operates as a division of the Michigan Economic Development Corporation. The goals of the program are as earlier mentioned, with additions aimed at reinforcing policy and program development; formation of public-private partnerships at local government levels; intensification of energy efficiency activities in the public and private sectors; and encouragement of the adoption of technologies and substitute fuels in buildings, alternative transportation fuel for vehicles, generation of power and industrial usage. SEP funds provide financial assistance through loans and grants to manufacturers of equipment for renewable energy and energy efficiency systems in Michigan.

Meta-Analysis of Energy Savings from Lighting Programs

The impetus and force gained by energy efficiency policy and programs in the context of sustainable development, led states and utilities to conduct studies that had the potential of energy savings in their region (Nadel, Shipley, & Elliot, 1994). The studies conducted in the 1980s and early 1990s aim to quantify energy efficiency resources, and recognize the opportunities for energy savings. The focus has been on energy efficiency as contemporary measures to save energy and mitigate associated negative impacts. Information available from findings helped inform decision-making on the size as well as the targets of energy efficiency programs.

According to U.S. DOE, states have passed legislation that offers energy incentives to residential, government, and commercial/industrial involved in energy-efficient programs, which are supported by the federal government (U.S. EERE, 2015). The goal is to encourage economic development through efficiency lighting options that are cost-effective for enhanced investment in the economy (EERE, 2015). Improvements in energy efficiency such as lighting has a large impact on states to reduce the pressure to build new power plants, cost of transmission and distribution, and ultimately register lower energy cost for ratepayer. Meta-analysis reduces the quantity of data from different utilities and other sources through summary of savings from the lighting programs considered with respect to the investment. This helps in efficient use of the data available in the databases for consistency, improvement in generalizability of findings, generation of hypothesis on energy savings from subgroups of the studies samples and provision of the needed information for administrators, policy makers and stakeholders, thereby reducing the time to design, plan, administer and implement the lighting programs. The energy efficiency policy impacts Michigan's economy study projections show improvement over base case in employment of 2000 jobs, disposable personal income of $180 million and gross state product (GSP) of $164 million by 2020. The decline in energy consumption (electricity) will defer the construction of new generation plants thereby reducing emissions, increasing new jobs in the energy industry, and boosting the economy through increases in disposable personal income, if Michigan moves as expected on policies that encourage the implementation of energy efficiency programs (Polich, Kulesia, Amlin, Levesque, & Winkelman, 2007).

Meta-analysis of 11 studies conducted on the technical, economic, and achievable potential for energy efficiency in the United States revealed these findings. Electricity had a median technical potential of 33%, median economic potential of 20% and achievable potential of 24%, which is an average of 0.5% per year. These findings were consistent when compared with recent actual savings from portfolios of electric in leading states such as California and Massachusetts among others (Nadel et al., 1994).

According to GDS Associates, Incorporated (2013) study on Michigan electric and natural gas energy efficiency potential study, technical potential is a theoretical amount of energy consumption reduction as a result of energy efficiency measures, without taking into consideration non-engineering limitations such as cost-effectiveness and the adoption rate of energy efficiency programs. Economic potential is a subset of technical potential that takes cost-effectiveness of the energy efficiency measures into considerations. In addition, technical and economical potentials as opposed to achievable potential do not take the ramping up period of the efficiency program that would happen in real-life situations into considerations, as the numbers quoted are theoretical for immediate implementation of the programs. Achievable potential is the amount of energy as demanded that can actually be saved for a vigorous program marketing policy that takes into consideration energy efficiency barriers such as financial, regulatory, administrators' capability for implementation, and political factors. This makes a case for a meta-analysis of energy savings from lighting programs in Michigan.

Although Michigan has made concerted efforts through policies and programs to promote energy efficiency, estimates of the costs and benefits of the policies and programs remain in dispute. The argument is whether there is an energy efficiency gap, in which energy consumers and firms do not make any savings in energy efficiency investments. Yet, to date, no empirical data have been published that summarize and integrate findings on energy savings from lighting programs in Michigan. Energy efficiency literature in Michigan shows that most of the data on energy savings from lighting programs available are not always separated under the considerations for the study, but aggregated within lighting programs or other energy efficiency saving measures, which makes it difficult if not impossible to apportion the savings attributable for each measure of efficient lighting in Michigan. In order to provide information on energy savings to justify the investments, it is imperative that a meta-analysis of the studies (quantitative measures) on savings on disaggregated findings be conducted to determine the effect, extent and efficacy of the policies and programs to inform decision-making. This study is able to provide an estimate in the evaluation context to fill the gap in aggregate energy savings and the impact of lighting efficiency programs in Michigan.

CHAPTER III

METHODOLOGY

This study used meta-analysis to determine both the overall effect size and individual effects size for the lighting programs for a random effects model. Meta-analysis is defined as the review and synthesis of all research or evaluation studies that had been conducted in a particular field (Bamberger, et al., 2012). In addition, the statistical technique can be looked at as survey research, in which research reports are surveyed, rather than people (Lipsey & Wilson, 2001). This section as shown in Figure 3.1 delineates the stages in meta-analysis, and employ a software

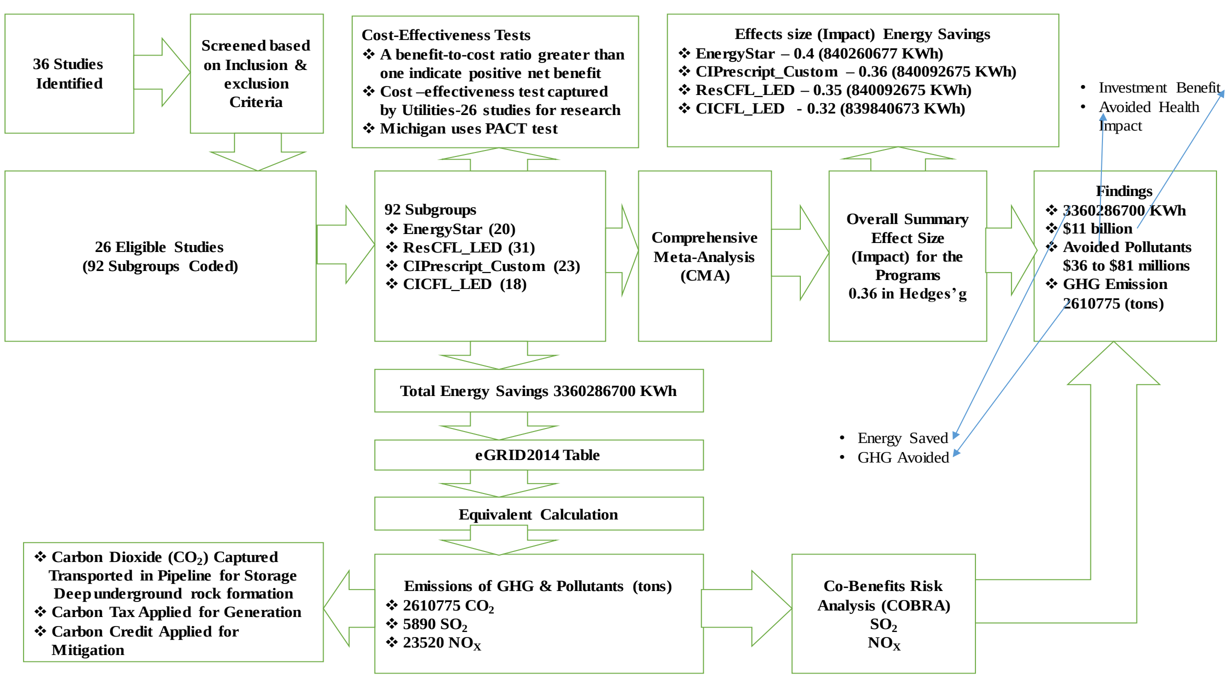


Figure 3.1. Input – Output Diagram for the Energy Savings

package, comprehensive meta-analysis (CMA), a Co-Benefits Risk Assessment (COBRA) screening model and an eGRID2014 year 2017 Summary Tables to answer the research questions. A total of 36 studies were identified and 26 met the selection criterion, while 10 were discarded for not meeting the selection criterion. The 26 studies produced 92 subgroups that were used as unit of analysis to compute the total energy saved as well as run CMA to determine the effects size. The corresponding value of energy saved was read on an eGRID2014 table to determine the amount of GHG emitted and Pollutants. The pollutants Sulphur dioxide and Nitrogen Oxides were used on the COBRA software to determine the air quality and health effects. The economic benefits value associated with health effects were displayed on table produced by the software. The stages for conducting meta-analysis include problem formulation, literature search, data evaluation, data analysis, interpretation of results, and presentation of results (Cooper et al., 2009; Cook et al., 1992; Lipsey & Wilson, 2001; Durlak & Lipsey, 1991). In summary, the stages of the research involve searching and selecting studies relevant to the research questions, coding the study patterns and determining inter-rater reliability, translating the study outcome into common metric, and analyzing and interpreting relations between study patterns and outcomes (Mathison, 2005). The subgroups were used as a unit of analysis, and each given a unique acronym for purpose of identification and space convenience. These include CICFL_LED Prgm for commercial/industrial compact fluorescent lamp and LED lamp, CIPrescript_Custom Prgm for commercial/industrial prescriptive and custom, EnergyStar Prgm for Energy Star and ResCFL_LED Prgm for residential compact fluorescent lamp and LED programs.

Problem Formulation

The study seeks to quantify energy savings, the dependent variable from lighting programs, which are the independent variables for the study in Michigan. These variables change over time due to the state of the economy, technology change, behavior, prices, and change in operational activities. Lighting programs considered for the energy efficiency (lighting efficiency) initiative include the residential compact fluorescent (CFLs) and light emitting diode (LED) lamps commercial/industrial fluorescent and LED retrofit lamps, Energy Star rebate lamps, and the commercial/industrial prescriptive and custom programs that falls between years 2006 through 2015 for an overall effect size and the individual programs effects size for a random effects model. Prescriptive programs for the commercial/industrial sector give rebates for lighting replacements, while the custom programs give rebates per KWh of electricity savings for industrial process improvements. The utility sector had been implementing lighting efficiency programs through electric and independent program administrators that utility customers' fund through utility rates. The approach for delivering lighting efficiency programs include financial incentives-rebates and loans, technical services-audits and retrofits, and educational enlightenment on the benefits of energy efficiency improvements. It is difficult to keep track of information on lighting efficiency programs activities released by the Federal and State government. Researchers interested in energy savings as a dependent variable of the different independent variables of lighting efficiency measures could easily be overwhelmed with such data. Systematic reviews or meta-analyses have been employed to limit bias through replicable scientific process that perform a literature search and assess the quality of individual studies (Crowther, Lim, & Crowther, 2010).

Therefore, the data of individual studies weighted and pooled by meta-analysis technique to give estimated effects on energy savings from lighting programs in Michigan. These questions guide the study: *In Michigan from 2006-2015, using meta-analysis, what is the impact of programs to create energy savings in lighting, and which programs are the most cost effective with respect to the investment?* The question is descriptive, and a quantitative estimate of the savings and the impact of the savings using a standardized mean difference Hedges' g due to the variations in energy savings measures is provided. This was accomplished by synthesizing and analyzing the lighting programs in Michigan considered for the study. The energy savings and resultant improvement in air quality and avoided health effects due to the program intervention answers the counterfactual question of the absence of energy efficiency measures, which responds to the second research question. *What is the total GHG emissions savings from the energy efficiency lighting? Which of the lighting efficiency gives the most GHG emissions savings?*

Literature Search

The study datasets were obtained from Consumers Energy on request and the studies came as attachments and links in the emails as earlier mentioned. In addition, the Michigan Energy Office and DTE studies were received as attachments and links respectively in the emails. Other datasets were obtained through an internet search of databases on the university website. The databases accessed for the study include Michigan Energy Measures Database (MEND), United State DOE, United States EIA, and PscyINFO. Others include the United States EPA, other Utilities, and the Northwest

Energy Efficiency Alliance (NEEA). Additional studies include unpublished studies, the Dissertation Abstracts International, Educational Resources Information Center (ERIC), conference proceedings and Google search using the following keywords and phrases in varied combinations: lighting efficiency, energy savings, energy efficiency programs in Michigan, meta-analysis of energy savings in Michigan, and consumption of energy from lighting programs in Michigan.

Data Evaluation

Criteria for Inclusion and Exclusion of Studies

In order to establish a pattern for the research studies, a doctoral student was hired to help code (26 studies) about 92 independent subgroups treated as independent studies that met the criteria set a priori before obtaining the studies. The coding was carried out by two coders who had an interrater reliability of 91.1% approximately. There were disagreements that were resolved at each stage of the coding exercise through periodic discussions to reach a consensus. These disagreements were over missing data, and the statistics of independent data variables to code in the event of incomplete information. The consensus as reached by the two coders on what to code on areas of disagreement prevailed. The eligible criteria for coding the studies included defining features, designs and methods, features of the sample, statistical data, geographical and linguistic restriction, time frame, and type of outcome measures. These are elaborated on below (Cooper et al., 2009).

i. Defining features-The empirical energy saving as recorded from lighting programs, and the relationship between the programs with the dependent variable, energy saved.
ii. Designs and Methods-Rigorous program activities of experimental and quasi-experimental studies are to be included. In addition, archival data of actual energy saved from activities of any of the lighting programs in Michigan included.
iii. Features of the Sample-Studies that record energy savings as a result of energy efficiency initiatives are included.
iv. Statistical data must be provided for computation of the effects size of individual programs.
v. Geographical and Linguistic Restrictions-The studies must be published in English, and should represent lighting programs in Michigan.
vi. Time Frame-Studies that fall between 2006 through 2015.
vii. Outcome Measures-Studies restricted to impact and process evaluation with quantitative outcome value on energy savings from lighting (lighting efficiency) programs

Exclusion Criteria

Studies that fail on one of the inclusion criteria were excluded. These include the defining features, designs and methods, features of the sample, statistical data, geographical and linguistic restriction, time frame, and studies restricted to process and impact evaluation with quantitative outcome value on energy savings from lighting (lighting efficiency) programs.

The selection of data for the lighting programs (lighting efficiency) consisted of a repository on energy saving between the years 2006 through 2015 in Michigan. The collection activity involves archival, library search, and web-based retrieval of relevant data from sources mentioned in the research design section. All studies included met the selection criteria for inclusion. The data as extracted was arranged on a prepared data report book according to title and date of extraction as a guide against double extraction. Studies were then coded as arranged a priori in the coding manual.

Data Analysis

A total of 36 studies were identified, which 10 were ineligible and 26 eligible studies with 92 independent subgroups were used for the research study. The 92 independent subgroups are treated as separate studies using Comprehensive Meta-analysis (CMA) software. Most of the independent actual studies have at least four independent subgroups that CMA treat as separate independent study for the analysis. There were four lighting programs considered for the research, and each study implement two or more of these programs to intervene for energy saving (Lighting efficiency) in Michigan. In order to capture the effect of each intervention by a program, subgroup was used as a unit of analysis to run the meta-analysis, since the primary goal of the analysis is to determine the overall and compare the impact of the four lighting programs considered.

Publication bias was tested to determine whether the overall effect is robust. *Classic Fail-Safe N, Orwin's Fail-Safe N*, which treats subgroups as independent studies for these test to be meaningful were conducted as test for the bias. Thereafter, Comprehensive meta-analysis (CMA) software was used to determine the individual effects size as well as the overall summary effect size (Cooper et al., 2009). An effect size is a number that indicates the extent of association between two variables. A standardized mean difference was computed, if a study reported the mean and standard deviation for the intervention, for example, an effect size in Hedges' g and variance were computed as input for the comprehensive meta-analysis software. Eligible studies used to run the analysis are tabled below.

Find as listed in Table 3.1 the 26 studies that generated 92 subgroups (studies) that met the criteria set a priori before coding, and used for the analysis by running CMA software.

The rationale for using meta-analysis is to detect a meaningful effect for studies that have small sizes, thus having a low statistical power. Meta-analysis increases the precision of the estimated association. When a large number of studies are combined, the sampling error of association for the study reduces. Another reason is to examine the improvement or negativity in causal outcome, and to strengthen the generalization of an association (Cooper et al., 2009). This is especially so with energy efficiency programs and policies that are determined in a particular context for each state.

Table 3.1

Eligible Studies for the Analysis

S/n	Studies
1	GDS Associates, Inc. Engineers & Consultants. (2013). Michigan Electric and Natural Gas Energy Efficiency Potential Study
2	The Cadmus Group, Inc. (2015). Residential Optimization Certtification Report. *2014 Program Year*
3	The Cadmus Group Inc. (2011). Michigan Baseline Study 2011. *Commercial Baseline Report*
4	The Cadmus Group Inc. (2011). Michigan Baseline Study 2011. Residential *Baseline Report*
5	Cadmus Navigant NMR Group. (2014). Michigan CFL Net-to-Gross Advisory Panel Final Report
6	DTE Energy(2011). Energy Optimization Annual Report
7	DTE Energy(2015). Energy Optimization Annual Report
8	Kema Incorporated. (2012). Bay City Electric Light and Power Verification of Savings of 2012 Energy Optimization Programs Final Report
9	Optimal Energy, Inc. Energy Future Group. (2013). Final Report: Alternative Michigan Energy Savings Goals to Promote Longer Term Savings And Address Small Utility Challenges
10	EMI Cosulting & Michigan Energy (2014). Michigan Statewide Commercial and Industrial Lighting Hours-of-Use Study
11	Consumers Energy(2013 [Amended]). Amended Energy Optimization Plan
12	Opinion Dynamics Corporation & Cadmus Group, Inc. (2012). CFL Hours of Use Study. *Summary of Approach and Results*
13	MPSC Case Number U-15885 (2011). Energy Optimization Annual Report for 2010
14	MPSC Case Number U-16275 (2014). Village of Union City Energy Optimization Annual Report for 2014
15	Opinion Dynamics Corporation; The Cadmus Group Inc. & Consumer Insights (2012). Impact and Process Evaluation of DTE Energy's 2011 Energy Optimization Programs (PY3)
16	DTE Energy(2012). Energy Optimization 2012 Annual Report
17	KEMA, INC. (2012). Impact Evaluation of Electric and natural Gas Energy Optimization Programs. *Impact Evaluation Results for Efficiency United*
18	KEMA, INC. (2013). Impact Evaluation of Electric and natural Gas Energy Optimization Programs. *Impact Evaluation Results for Efficiency United*
19	Consumers Energy (2009). Energy Optimization Annual Report
20	Consumers Energy (2010). Energy Optimization Annual Report
21	Consumers Energy (2011). Energy Optimization Annual Report
22	Consumers Energy (2012). Energy Optimization Annual Report
23	Consumers Energy (2013). Energy Optimization Annual Report
24	Consumers Energy (2014). Energy Optimization Annual Report
25	Consumers Energy (2015). Energy Optimization Annual Report
26	EMI Cosulting (2015). Evaluator Certification of Consumers Energy's Commercial and Industrial Reported Savings

However, the software was employed after study patterns were established through coding of the studies. The software displays descriptive tables of graphical and statistical analysis that help explain certain parameters of interest, the effects size of the studies, an overall summary effect size, and other statistics that help explain the analysis. These include the effects size in Hedges' g, the variances, standard error, confidence interval at 95%, z-value and the p-value set at alpha level of 0.05. Other parameters of importance displayed by the software include the heterogeneity statistics Q, a measure of weighted squared deviations I^2, ratio of true heterogeneity to total observed variation and a p-value, a test of the null hypothesis that all studies share common effect sizes and the true variation of the effects of the lighting program (Borenstein et al., 2009)

Interpretation of Results

The cumulative research evidence concerning the strengths, generality, and limitations of the findings help to draw conclusions. The effect size, a value that indicates the magnitude of an intervention or the strength of association between two variables is the metric in meta-analysis. The size of an effects size indicates the impact of an intervention, such as the impact of energy savings with respect to the investment or reduction in emission for improved health, for example. In addition, the strength of the association reported is the standardized mean difference Hedges' *g*, which the study used to transform all effects' sizes of the studies to a common metric.

The Campbell Collaboration systematic reviews on intervention serve as a guide to help in interpreting the study outcome. This distinguishes meta-analysis, a systematic review from traditional narrative reviews to achieve reliable estimates of effects. In addition, the guide provides guidance on systematic reviews, and creates a minimum standard to retrieve information from compiled studies. It has a meta-analysis effect-size calculator that is web-based. The calculator assists in the computation of four effect-sizes from input data of studies. These include the standardized mean difference, the correlation coefficient, the risk ratio and odd ratio

Limitations

The study is limited in the absence of studies from 2006 to 2008, because of the absence of energy efficiency programs during the period in Michigan. Michigan actually signed into law the Energy Optimization (EO) standard, PA 295 of 2008, and actually started implementation in 2009 until today (Quackenbush et at., 2015). Another limitation was access to unpublished dissertations and published work on lighting programs in Michigan. The majority of literature on lighting programs (energy efficiency) in the state were narrative in nature that lack quantitative measures for inclusion in the study. In addition, data received from utilities reveals gaps in some of the information needed (investment amount and benefit-cost ratio) for a complete analysis, which lead to discarding such data sets for others, and ending up with a small representation of data in some lighting programs. Other limitations of the study include immediate or future changes in standards for lighting and appliance.

CHAPTER IV

RESULTS

This study analyzes ninety-two studies that met the eligible criteria set a priori in the method chapter of the report. Table 4.1 contains ineligible and eligible studies used in the study.

Table 4.1

Ineligible Studies for Exclusion

S/N	Name of Study	Reason for Ineligibility
1	Kema, Inc. (2012). Process Evaluation of Electric and Natural Gas Energy Optimization Programs	Data for computing effects sizes not provided
2	Kema, Inc. (2013). Process Evaluation of Electric and Natural Gas Energy Optimization Programs	Statistical data for computing effects sizes not provided in the study
3	Quackenbus, et al. (2015). Reports on the Implementation of the P.A. 295 Renewable Energy Standard and Cost-Effectivenss of the Energy Standards	The Statistics given is not dissaggregated to capture lighting as a unique measure for the study
4	Optimal Energy Inc. & Angelou Economics (2011). Economics Impacts of P.A. 295 Energy Optimization Investments in Michigan	Narrative Submission without data for computing effect sizes
5	Optimal Energy, Inc. (2013). Options for Establishing Energy Efficiency Targets in Michigan 2016-2020	The timing and forecast falls outside the time frame for the study that is 2006 through 2015
6	MPSC. (2005). Michigan Energy Appraisal. *Michigan Department of Labor and Economics*	Discusses Primary fuels. Energy savings data not provided
7	Lark, J.P. (2007). Michigan's 21st Electric Energy Plan	No recorded data on energy savings for specific year
8	Michigan Conservative Forum. (2014 - 2023). Economic Impacs of Impacts of Energy Optimization Program. *Scenarios in Michigan, 2014 to 2013*	No data provided for savings, computation of effects sizes and investments
9	Lesser, J. & O' Conor, R.P. (2013). Retail Electric Choice Opponents in Michigan. *Excuses and Obsfuscation*	Electric marketing rates without any energy savings data
10	Energy Optimization. Residential Efficiency Programs. Retrievable at http://www.Michigan-energy.org/	Absence of data for computation of effect sizes

Impact of Lighting Programs in Michigan

The eligible studies numbering 92 are as depicted in Figure 4.1 of the forest plot as well as Table 4.2, gives an overall summary effect (the estimates of the true effects and the null hypothesis that the mean of these effects is zero) in Hedge's g of 0.36 with confidence interval of between 0.315 to 0.405 for a random effects model. The standard error for the summary effect is 0.023 and a p-value for a test of the null as 0.000 that is less than 0.05 level of alpha. This gives a significant value; hence the null hypothesis is rejected. The within and across are the sources of variations.

Table 4.2

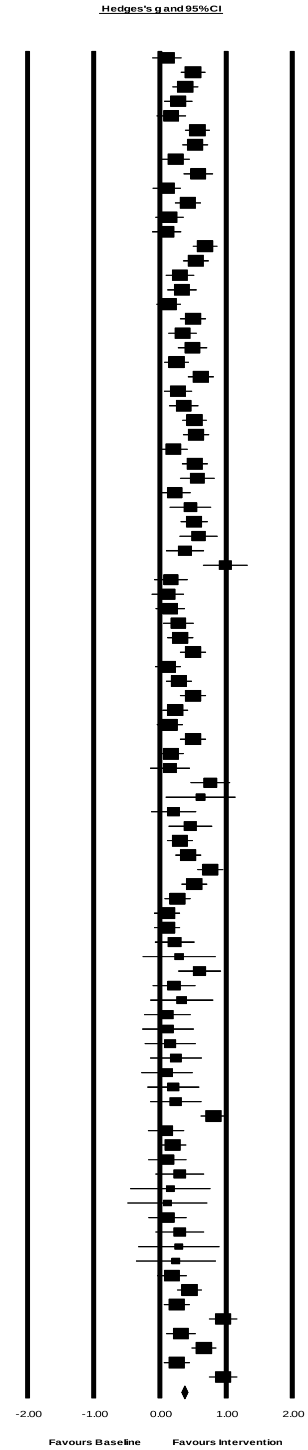
Overall Effects Size for Energy Efficiency

Model		Effect size and 95% confidence interval					Test of null (2-Tail)		Heterogeneity				Tau-squared			
Model	Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed	92	0.370	0.013	0.000	0.345	0.396	28.825	0.000	274.713	91.000	0.000	66.875	0.031	0.007	0.000	0.175
Random effects	92	0.360	0.023	0.001	0.315	0.405	15.613	0.000								

The Q-statistics (hypothesize that all studies share the same effect), with a p-value of 0.000 at 0.05 level of alpha, leads to the rejection of the null that the lighting programs do share a common effect size. The value of the Q, the observed variation and df(Q) is 274.713 and 91.000 respectively. This gives the excess variation of 183.713 that is attributed to the differences in the true impact from study to study of the lighting

Forest Plot of the Overall Summary Effect Size For the Lighting Programs

Study name	Subgroup within study	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
		Statistics for each study						
CE Energy 2009	CICFL_LED Pgrm	0.105	0.118	0.014	-0.127	0.337	0.887	0.375
CE Energy 2009	CIPres_CustPrgm	0.500	0.100	0.010	0.304	0.696	5.000	0.000
CE Energy 2009	EnergyStar Prgm	0.383	0.105	0.011	0.177	0.589	3.652	0.000
CE Energy 2009	ResCFL_LED Prgm	0.277	0.114	0.013	0.054	0.500	2.429	0.015
CE Energy 2010	CICFL_LED Pgrm	0.171	0.118	0.014	-0.061	0.403	1.445	0.148
CE Energy 2010	CIPres_CustPrgm	0.566	0.100	0.010	0.370	0.762	5.660	0.000
CE Energy 2010	EnergyStar Prgm	0.533	0.105	0.011	0.327	0.739	5.082	0.000
CE Energy 2010	ResCFL_LED Prgm	0.237	0.114	0.013	0.014	0.460	2.079	0.038
CE Energy 2011	CICFL_LED Pgrm	0.578	0.118	0.014	0.346	0.810	4.885	0.000
CE Energy 2011	CIPres_CustPrgm	0.103	0.114	0.013	-0.120	0.326	0.903	0.366
CE Energy 2011	EnergyStar Prgm	0.422	0.105	0.011	0.216	0.628	4.024	0.000
CE Energy 2011	ResCFL_LED Prgm	0.145	0.114	0.013	-0.078	0.368	1.272	0.203
CE Energy 2012	CICFL_LED Pgrm	0.101	0.118	0.014	-0.131	0.333	0.854	0.393
CE Energy 2012	CIPres_CustPrgm	0.681	0.100	0.010	0.485	0.877	6.810	0.000
CE Energy 2012	EnergyStar Prgm	0.543	0.105	0.011	0.337	0.749	5.177	0.000
CE Energy 2012	ResCFL_LED Prgm	0.302	0.114	0.013	0.079	0.525	2.649	0.008
CE Energy 2013	CICFL_LED Pgrm	0.333	0.118	0.014	0.101	0.565	2.814	0.005
CE Energy 2013	CIPres_CustPrgm	0.133	0.100	0.010	-0.063	0.329	1.330	0.184
CE Energy 2013	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
CE Energy 2013	ResCFL_LED Prgm	0.342	0.114	0.013	0.119	0.565	3.000	0.003
CE Energy 2014	CICFL_LED Pgrm	0.492	0.118	0.014	0.260	0.724	4.158	0.000
CE Energy 2014	CIPres_CustPrgm	0.252	0.100	0.010	0.056	0.448	2.520	0.012
CE Energy 2014	EnergyStar Prgm	0.618	0.105	0.011	0.412	0.824	5.892	0.000
CE Energy 2014	ResCFL_LED Prgm	0.273	0.114	0.013	0.050	0.496	2.394	0.017
CE Energy 2015	CICFL_LED Pgrm	0.359	0.118	0.014	0.127	0.591	3.034	0.002
CE Energy 2015	CIPres_CustPrgm	0.523	0.100	0.010	0.327	0.719	5.230	0.000
CE Energy 2015	EnergyStar Prgm	0.546	0.105	0.011	0.340	0.752	5.206	0.000
CE Energy 2015	ResCFL_LED Prgm	0.204	0.114	0.013	-0.019	0.427	1.789	0.074
Kema Inc 2012	CICFL_LED Pgrm	0.527	0.105	0.011	0.321	0.733	5.025	0.000
Kema Inc 2012	CIPres_CustPrgm	0.566	0.138	0.019	0.296	0.836	4.106	0.000
Kema Inc 2012	EnergyStar Prgm	0.224	0.126	0.016	-0.024	0.472	1.771	0.077
Kema Inc 2012	ResCFL_LED Prgm	0.461	0.164	0.027	0.139	0.783	2.806	0.005
Kema Inc 2013	CICFL_LED Pgrm	0.517	0.110	0.012	0.302	0.732	4.720	0.000
Kema Inc 2013	CIPres_CustPrgm	0.583	0.152	0.023	0.286	0.880	3.844	0.000
Kema Inc 2013	EnergyStar Prgm	0.379	0.152	0.023	0.082	0.676	2.499	0.012
Kema Inc 2013	ResCFL_LED Prgm	0.988	0.176	0.031	0.643	1.333	5.611	0.000
DTE Energy 2011	CICFL_LED Pgrm	0.166	0.134	0.018	-0.097	0.429	1.237	0.216
DTE Energy 2011	CIPres_CustPrgm	0.119	0.130	0.017	-0.137	0.375	0.913	0.361
DTE Energy 2011	EnergyStar Prgm	0.156	0.118	0.014	-0.076	0.388	1.318	0.187
DTE Energy 2011	ResCFL_LED Prgm	0.278	0.122	0.015	0.038	0.518	2.270	0.023
DTEEnergy13 2015	CIPres_CustPrgm	0.307	0.105	0.011	0.101	0.513	2.927	0.003
DTEEnergy13 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
DTEEnergy13 2015	ResCFL_LED Prgm	0.121	0.105	0.011	-0.085	0.327	1.154	0.249
DTEEnergy14 2015	CIPres_CustPrgm	0.287	0.105	0.011	0.081	0.493	2.736	0.006
DTEEnergy14 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
DTEEnergy14 2015	ResCFL_LED Prgm	0.230	0.105	0.011	0.024	0.436	2.193	0.028
DTEEnergy15 2015	CIPres_CustPrgm	0.148	0.105	0.011	-0.058	0.354	1.411	0.158
DTEEnergy15 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
DTEEnergy15 2015	ResCFL_LED Prgm	0.165	0.105	0.011	-0.041	0.371	1.573	0.116
EMI Consulting 2015	CICFL_LED Pgrm	0.152	0.158	0.025	-0.158	0.462	0.961	0.336
EMI Consulting 2015	CIPres_CustPrgm	0.761	0.158	0.025	0.451	1.071	4.813	0.000
The Cadmus Inc 2015	EnergyStar Prgm	0.613	0.274	0.075	0.076	1.150	2.238	0.025
The Cadmus Inc 2011	CICFL_LED Pgrm	0.207	0.179	0.032	-0.144	0.558	1.157	0.247
The Cadmus Inc 2011	ResCFL_LED Prgm	0.459	0.173	0.030	0.120	0.798	2.650	0.008
Cadmus09 2014	ResCFL_LED Prgm	0.303	0.105	0.011	0.097	0.509	2.889	0.004
Cadmus10 2014	ResCFL_LED Prgm	0.427	0.105	0.011	0.221	0.633	4.071	0.000
Cadmus11 2014	ResCFL_LED Prgm	0.761	0.105	0.011	0.555	0.967	7.256	0.000
Cadmus12 2014	ResCFL_LED Prgm	0.520	0.105	0.011	0.314	0.726	4.958	0.000
Cadmus13 2014	ResCFL_LED Prgm	0.265	0.105	0.011	0.059	0.471	2.527	0.012
Cadmus14 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
Cadmus15 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
OptimalEnergy Inc. 2013	EnergyStar Prgm	0.222	0.158	0.025	-0.088	0.532	1.404	0.160
Kema Inc09 2012	CICFL_LED Pgrm	0.291	0.286	0.082	-0.270	0.852	1.016	0.310
Kema Inc09 2012	ResCFL_LED Prgm	0.598	0.170	0.029	0.264	0.932	3.512	0.000
KemaIIInc09 2012	CIPres_CustPrgm	0.213	0.170	0.029	-0.121	0.547	1.251	0.211
Kema10 2012	ResCFL_LED Prgm	0.329	0.247	0.061	-0.155	0.813	1.332	0.183
Opinion Dynamics etal 2012	ResCFL_LED Prgm	0.111	0.184	0.034	-0.250	0.472	0.602	0.547
MPSC# U-15885 2011	CIPres_CustPrgm	0.121	0.205	0.042	-0.281	0.523	0.590	0.555
MPSC# U-15885 2011	ResCFL_LED Prgm	0.156	0.202	0.041	-0.241	0.553	0.770	0.441
MPSC11U-15885 2011	CIPres_CustPrgm	0.241	0.205	0.042	-0.161	0.643	1.176	0.240
MPSC11U-15885 2011	ResCFL_LED Prgm	0.107	0.202	0.041	-0.290	0.504	0.528	0.597
MPSC# U-16275 2014	CIPres_CustPrgm	0.202	0.205	0.042	-0.200	0.604	0.986	0.324
MPSC# U-16275 2014	ResCFL_LED Prgm	0.239	0.202	0.041	-0.158	0.636	1.180	0.238
DTE Energy 2012	CICFL_LED Pgrm	0.809	0.105	0.011	0.603	1.015	7.714	0.000
OpinionDynamics Corp. 2012	CIPres_CustPrgm	0.092	0.145	0.021	-0.192	0.376	0.635	0.526
OpinionDynamics Corp. 2012	EnergyStar Prgm	0.192	0.110	0.012	-0.023	0.407	1.753	0.080
GDSAssociates14 2013	CICFL_LED Pgrm	0.111	0.152	0.023	-0.186	0.408	0.732	0.464
GDSAssociates14 2013	CIPres_CustPrgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
GDSAssociates14 2013	EnergyStar Prgm	0.156	0.315	0.099	-0.461	0.773	0.496	0.620
GDSAssociates14 2013	ResCFL_LED Prgm	0.113	0.313	0.098	-0.501	0.727	0.361	0.718
GDSAssociates15 2013	CICFL_LED Pgrm	0.113	0.152	0.023	-0.184	0.410	0.745	0.456
GDSAssociates15 2013	CIPres_CustPrgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
GDSAssociates15 2013	EnergyStar Prgm	0.285	0.318	0.101	-0.338	0.908	0.897	0.370
GDSAssociates15 2013	ResCFL_LED Prgm	0.240	0.313	0.098	-0.374	0.854	0.767	0.443
CEEnergy[Amended14] 2013	CICFL_LED Pgrm	0.182	0.118	0.014	-0.050	0.414	1.538	0.124
CEEnergy[Amended14] 2013	CIPres_CustPrgm	0.447	0.100	0.010	0.251	0.643	4.470	0.000
CEEnergy[Amended14] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
CEEnergy[Amended14] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
CEEnergy[Amended15] 2013	CICFL_LED Pgrm	0.318	0.118	0.014	0.086	0.550	2.688	0.007
CEEnergy[Amended15] 2013	CIPres_CustPrgm	0.664	0.100	0.010	0.468	0.860	6.640	0.000
CEEnergy[Amended15] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
CEEnergy[Amended15] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
		0.360	0.023	0.001	0.315	0.405	15.613	0.000



Random Effects Model

Figure 4.1. Forest Plot for a Random Effects Model of the Summary Effect Size

programs. The I^2 statistics from the plot is 66.875%, a measure of proportion of the variation in observed effects that is due to true effects of the lighting programs. What this implies is that the variation in observed impacts of the lighting programs is as a result of the sampling error and the true variation of the impacts, and if we get rid of the sampling error, the proportion that would remain would be due to the variation in true impacts. However, I^2 shows only the proportion of variance that is true without mention of the absolute value of the variance. Another value *Tau-Squared* (T^2), the estimated variance of the observed effects in the figure shows the absolute value of the true variance without mention of the proportion of observed variance that is true. The value for the analysis is 0.031 and *Tau* (T), the estimated standard deviation is 0.175 of the overall lighting programs. The absolute variability is dispersed within a range referred to as prediction interval, which is calculated from a population sample as thus:

$$LL_{pred.} = M^{*} - t^{\alpha}_{df} \sqrt{T^2 + V_M^{*}} \quad \ldots \quad 1$$

$$UL_{Pred.} = M^{*} + t^{\alpha}_{df} \sqrt{T^2 + V_M^{*}} \quad \ldots \quad 2.$$

where M^* is the mean effect size in the sample, T^2 is the sample estimate of the variance of true effects size, V_M^* is the variance of M^* and $LL_{pred.}$ and $UL_{Pred.}$ are the lower and upper limits of the effects sizes respectively (Borenstein et al., 2009). Now, from the values of the analysis, where M^* is 0.360 as depicted in the forest plot, T^2 is 0.031, V_M^* is 0.000 and t^{α}_{df} is a t-value that corresponds to $\alpha = 0.05$, the 95% interval for a 90 degrees of freedom value of 1.986675, thus giving the prediction interval from 0.010 to0.709 for a 0.360 summary effects size. This shows that there is a true variation in the effects sizes of the lighting programs, which are later shown during comparison of the lighting programs in Michigan.

Sensitivity Analysis

The questions addressed by the sensitivity analysis in this study include studies with small impact and large impact for the lighting programs. One study each of small and large effects size were removed in turn to see if there was a change in the effect, and the summary effect for the random effects model was the same. However, the effects shifted downward when five studies each of small and large effects size were removed in turn. Essentially, the result of the study shows that there were no influential studies, so the T^2 from the analysis reflects the absolute value of true variance in the lighting programs.

Another technique known as the funnel plot is used for the study to display the relationship between study and effects size of the meta-analysis result for the lighting programs in Michigan. A funnel plot is looked at as a scatterplot that display the sample size on the y-axis and the estimated effect size on the x-axis. However, the standard error is used on the y-axis rather than sample size to take advantage of the spread of the points on the lower part of the scale that the smaller studies get plotted (Borenstein et al., 2009 & Copper et al., 2009). The funnel plot visually appears to be asymmetric, with most of the smaller studies clustering to the left of the mean. Studies that are larger appear toward the top of the funnel plot, clustering near the mean effect size. In the absence of higher concentrations of smaller studies on one side of the mean than the other, which would have been an indication of having smaller studies published because of having larger than average effects that meets the criterion of significance.

The funnel plot displayed in Figure 4.2 gives an unbiased estimate of the effect size as advanced by other earlier estimates. The result presented so far has been on the overall program effect size as an unbiased estimate of summary effect, and the heterogeneity associated with the lighting programs.

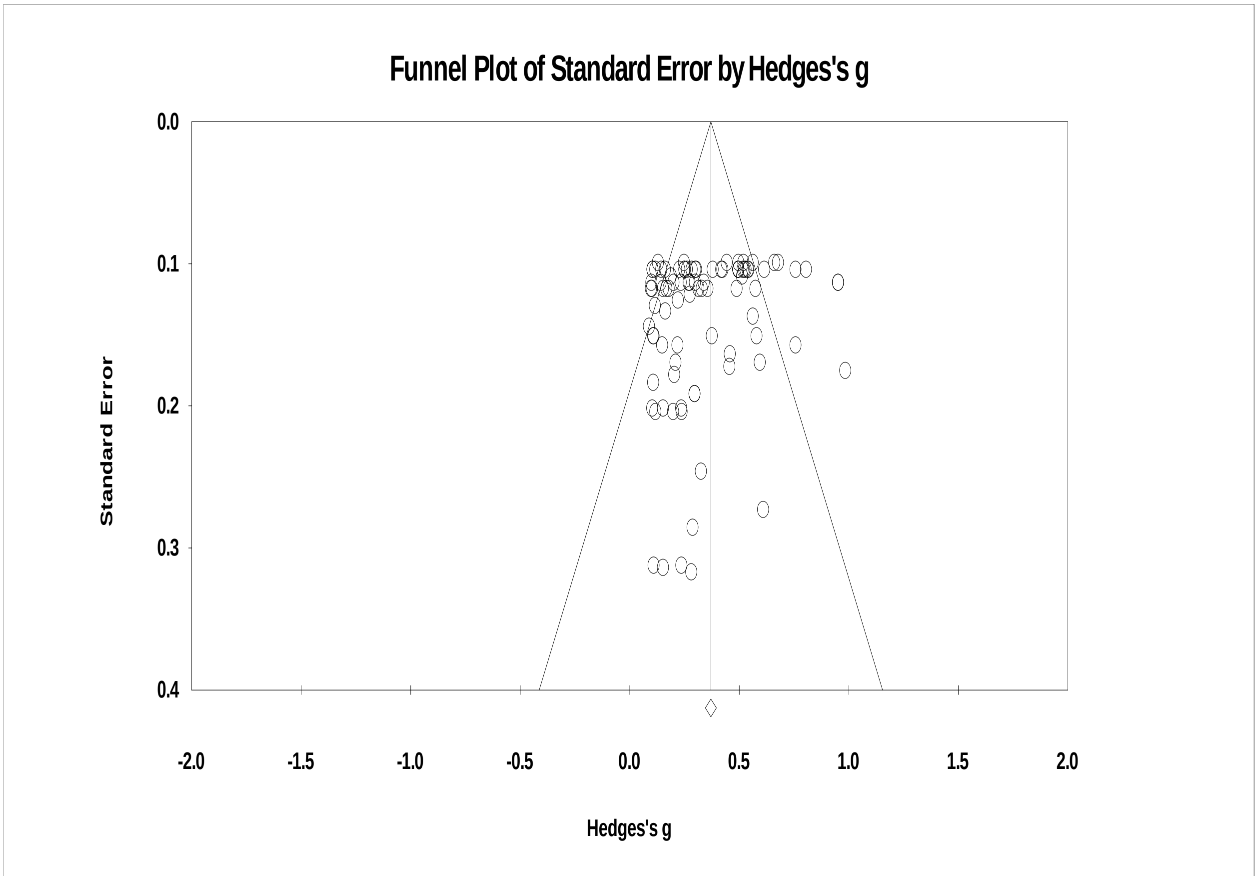
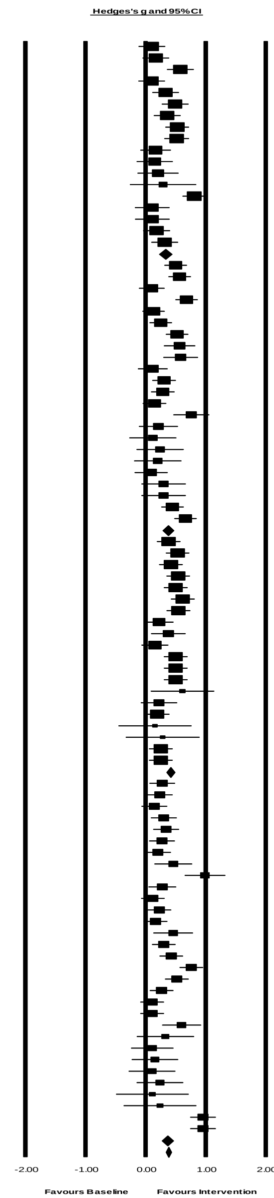


Figure 4.2. Funnel Plot of the Lighting Programs

Next, a forest plot that compares the effect size of each of the program is displayed, as well as one that compares the effects size of two programs at a time. The effects size of the lighting programs in Hedges' g are displayed in Figure 4.3 as well as Table 4.3, giving a value of 0.319 for the commercial/industrial compact fluorescent

Forest Plot of individual Effects Size For the Lighting Programs

Group by Subgroup within study	Study name	Subgroup within study	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
CICFL_LED Pgrm	CE Energy 2009	CICFL_LED Pgrm	0.105	0.118	0.014	-0.127	0.337	0.887	0.375
CICFL_LED Pgrm	CE Energy 2010	CICFL_LED Pgrm	0.171	0.118	0.014	-0.061	0.403	1.445	0.148
CICFL_LED Pgrm	CE Energy 2011	CICFL_LED Pgrm	0.578	0.118	0.014	0.346	0.810	4.885	0.000
CICFL_LED Pgrm	CE Energy 2012	CICFL_LED Pgrm	0.101	0.118	0.014	-0.131	0.333	0.854	0.393
CICFL_LED Pgrm	CE Energy 2013	CICFL_LED Pgrm	0.333	0.118	0.014	0.101	0.565	2.814	0.005
CICFL_LED Pgrm	CE Energy 2014	CICFL_LED Pgrm	0.492	0.118	0.014	0.260	0.724	4.158	0.000
CICFL_LED Pgrm	CE Energy 2015	CICFL_LED Pgrm	0.359	0.118	0.014	0.127	0.591	3.034	0.002
CICFL_LED Pgrm	Kema Inc 2012	CICFL_LED Pgrm	0.527	0.105	0.011	0.321	0.733	5.025	0.000
CICFL_LED Pgrm	Kema Inc 2013	CICFL_LED Pgrm	0.517	0.110	0.012	0.302	0.732	4.720	0.000
CICFL_LED Pgrm	DTE Energy 2011	CICFL_LED Pgrm	0.166	0.134	0.018	-0.097	0.429	1.237	0.216
CICFL_LED Pgrm	EMI Consulting 2015	CICFL_LED Pgrm	0.152	0.158	0.025	-0.158	0.462	0.961	0.336
CICFL_LED Pgrm	The Cadmus Inc 2011	CICFL_LED Pgrm	0.207	0.179	0.032	-0.144	0.558	1.157	0.247
CICFL_LED Pgrm	Kema Inc09 2012	CICFL_LED Pgrm	0.291	0.286	0.082	-0.270	0.852	1.016	0.310
CICFL_LED Pgrm	DTE Energy 2012	CICFL_LED Pgrm	0.809	0.105	0.011	0.603	1.015	7.714	0.000
CICFL_LED Pgrm	GDSAssociates14 2013	CICFL_LED Pgrm	0.111	0.152	0.023	-0.186	0.408	0.732	0.464
CICFL_LED Pgrm	GDSAssociates15 2013	CICFL_LED Pgrm	0.113	0.152	0.023	-0.184	0.410	0.745	0.456
CICFL_LED Pgrm	CEEnergy[Amended14] 2013	CICFL_LED Pgrm	0.182	0.118	0.014	-0.050	0.414	1.538	0.124
CICFL_LED Pgrm	CEEnergy[Amended15] 2013	CICFL_LED Pgrm	0.318	0.118	0.014	0.086	0.550	2.688	0.007
CICFL_LED Pgrm			0.319	0.053	0.003	0.216	0.423	6.055	0.000
CIPres_Cust Prgm	CE Energy 2009	CIPres_Cust Prgm	0.500	0.100	0.010	0.304	0.696	5.000	0.000
CIPres_Cust Prgm	CE Energy 2010	CIPres_Cust Prgm	0.566	0.100	0.010	0.370	0.762	5.660	0.000
CIPres_Cust Prgm	CE Energy 2011	CIPres_Cust Prgm	0.103	0.114	0.013	-0.120	0.326	0.903	0.366
CIPres_Cust Prgm	CE Energy 2012	CIPres_Cust Prgm	0.681	0.100	0.010	0.485	0.877	6.810	0.000
CIPres_Cust Prgm	CE Energy 2013	CIPres_Cust Prgm	0.133	0.100	0.010	-0.063	0.329	1.330	0.184
CIPres_Cust Prgm	CE Energy 2014	CIPres_Cust Prgm	0.252	0.100	0.010	0.056	0.448	2.520	0.012
CIPres_Cust Prgm	CE Energy 2015	CIPres_Cust Prgm	0.523	0.100	0.010	0.327	0.719	5.230	0.000
CIPres_Cust Prgm	Kema Inc 2012	CIPres_Cust Prgm	0.566	0.138	0.019	0.296	0.836	4.106	0.000
CIPres_Cust Prgm	Kema Inc 2013	CIPres_Cust Prgm	0.583	0.152	0.023	0.286	0.880	3.844	0.000
CIPres_Cust Prgm	DTE Energy 2011	CIPres_Cust Prgm	0.119	0.130	0.017	-0.137	0.375	0.913	0.361
CIPres_Cust Prgm	DTEEnergy13 2015	CIPres_Cust Prgm	0.307	0.105	0.011	0.101	0.513	2.927	0.003
CIPres_Cust Prgm	DTEEnergy14 2015	CIPres_Cust Prgm	0.287	0.105	0.011	0.081	0.493	2.736	0.006
CIPres_Cust Prgm	DTEEnergy15 2015	CIPres_Cust Prgm	0.148	0.105	0.011	-0.058	0.354	1.411	0.158
CIPres_Cust Prgm	EMI Consulting 2015	CIPres_Cust Prgm	0.761	0.158	0.025	0.451	1.071	4.813	0.000
CIPres_Cust Prgm	KemaIInc09 2012	CIPres_Cust Prgm	0.213	0.170	0.029	-0.121	0.547	1.251	0.211
CIPres_Cust Prgm	MPSC# U-15885 2011	CIPres_Cust Prgm	0.121	0.205	0.042	-0.281	0.523	0.590	0.555
CIPres_Cust Prgm	MPSC11U-15885 2011	CIPres_Cust Prgm	0.241	0.205	0.042	-0.161	0.643	1.176	0.240
CIPres_Cust Prgm	MPSC# U-16275 2014	CIPres_Cust Prgm	0.202	0.205	0.042	-0.200	0.604	0.986	0.324
CIPres_Cust Prgm	OpinionDynamics Corp. 2012	CIPres_Cust Prgm	0.092	0.145	0.021	-0.192	0.376	0.635	0.526
CIPres_Cust Prgm	GDSAssociates14 2013	CIPres_Cust Prgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
CIPres_Cust Prgm	GDSAssociates15 2013	CIPres_Cust Prgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
CIPres_Cust Prgm	CEEnergy[Amended14] 2013	CIPres_Cust Prgm	0.447	0.100	0.010	0.251	0.643	4.470	0.000
CIPres_Cust Prgm	CEEnergy[Amended15] 2013	CIPres_Cust Prgm	0.664	0.100	0.010	0.468	0.860	6.640	0.000
CIPres_Cust Prgm			0.364	0.045	0.002	0.275	0.453	8.014	0.000
EnergyStar Prgm	CE Energy 2009	EnergyStar Prgm	0.383	0.105	0.011	0.177	0.589	3.652	0.000
EnergyStar Prgm	CE Energy 2010	EnergyStar Prgm	0.533	0.105	0.011	0.327	0.739	5.082	0.000
EnergyStar Prgm	CE Energy 2011	EnergyStar Prgm	0.422	0.105	0.011	0.216	0.628	4.024	0.000
EnergyStar Prgm	CE Energy 2012	EnergyStar Prgm	0.543	0.105	0.011	0.337	0.749	5.177	0.000
EnergyStar Prgm	CE Energy 2013	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	CE Energy 2014	EnergyStar Prgm	0.618	0.105	0.011	0.412	0.824	5.892	0.000
EnergyStar Prgm	CE Energy 2015	EnergyStar Prgm	0.546	0.105	0.011	0.340	0.752	5.206	0.000
EnergyStar Prgm	Kema Inc 2012	EnergyStar Prgm	0.224	0.126	0.016	-0.024	0.472	1.771	0.077
EnergyStar Prgm	Kema Inc 2013	EnergyStar Prgm	0.379	0.152	0.023	0.082	0.676	2.499	0.012
EnergyStar Prgm	DTE Energy 2011	EnergyStar Prgm	0.156	0.118	0.014	-0.076	0.388	1.318	0.187
EnergyStar Prgm	DTEEnergy13 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	DTEEnergy14 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	DTEEnergy15 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	The Cadmus Inc 2015	EnergyStar Prgm	0.613	0.274	0.075	0.076	1.150	2.238	0.025
EnergyStar Prgm	OptimalEnergy Inc. 2013	EnergyStar Prgm	0.222	0.158	0.025	-0.088	0.532	1.404	0.160
EnergyStar Prgm	OpinionDynamics Corp. 2012	EnergyStar Prgm	0.192	0.110	0.012	-0.023	0.407	1.753	0.080
EnergyStar Prgm	GDSAssociates14 2013	EnergyStar Prgm	0.156	0.315	0.099	-0.461	0.773	0.496	0.620
EnergyStar Prgm	GDSAssociates15 2013	EnergyStar Prgm	0.285	0.318	0.101	-0.338	0.908	0.897	0.370
EnergyStar Prgm	CEEnergy[Amended14] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
EnergyStar Prgm	CEEnergy[Amended15] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
EnergyStar Prgm			0.405	0.034	0.001	0.338	0.471	11.910	0.000
ResCFL_LED Prgm	CE Energy 2009	ResCFL_LED Prgm	0.277	0.114	0.013	0.054	0.500	2.429	0.015
ResCFL_LED Prgm	CE Energy 2010	ResCFL_LED Prgm	0.237	0.114	0.013	0.014	0.460	2.079	0.038
ResCFL_LED Prgm	CE Energy 2011	ResCFL_LED Prgm	0.145	0.114	0.013	-0.078	0.368	1.272	0.203
ResCFL_LED Prgm	CE Energy 2012	ResCFL_LED Prgm	0.302	0.114	0.013	0.079	0.525	2.649	0.008
ResCFL_LED Prgm	CE Energy 2013	ResCFL_LED Prgm	0.342	0.114	0.013	0.119	0.565	3.000	0.003
ResCFL_LED Prgm	CE Energy 2014	ResCFL_LED Prgm	0.273	0.114	0.013	0.050	0.496	2.394	0.017
ResCFL_LED Prgm	CE Energy 2015	ResCFL_LED Prgm	0.204	0.114	0.013	-0.019	0.427	1.789	0.074
ResCFL_LED Prgm	Kema Inc 2012	ResCFL_LED Prgm	0.461	0.164	0.027	0.139	0.783	2.806	0.005
ResCFL_LED Prgm	Kema Inc 2013	ResCFL_LED Prgm	0.988	0.176	0.031	0.643	1.333	5.611	0.000
ResCFL_LED Prgm	DTE Energy 2011	ResCFL_LED Prgm	0.278	0.122	0.015	0.038	0.518	2.270	0.023
ResCFL_LED Prgm	DTEEnergy13 2015	ResCFL_LED Prgm	0.121	0.105	0.011	-0.085	0.327	1.154	0.249
ResCFL_LED Prgm	DTEEnergy14 2015	ResCFL_LED Prgm	0.230	0.105	0.011	0.024	0.436	2.193	0.028
ResCFL_LED Prgm	DTEEnergy15 2015	ResCFL_LED Prgm	0.165	0.105	0.011	-0.041	0.371	1.573	0.116
ResCFL_LED Prgm	The Cadmus Inc 2011	ResCFL_LED Prgm	0.459	0.173	0.030	0.120	0.798	2.650	0.008
ResCFL_LED Prgm	Cadmus09 2014	ResCFL_LED Prgm	0.303	0.105	0.011	0.097	0.509	2.889	0.004
ResCFL_LED Prgm	Cadmus10 2014	ResCFL_LED Prgm	0.427	0.105	0.011	0.221	0.633	4.071	0.000
ResCFL_LED Prgm	Cadmus11 2014	ResCFL_LED Prgm	0.761	0.105	0.011	0.555	0.967	7.256	0.000
ResCFL_LED Prgm	Cadmus12 2014	ResCFL_LED Prgm	0.520	0.105	0.011	0.314	0.726	4.958	0.000
ResCFL_LED Prgm	Cadmus13 2014	ResCFL_LED Prgm	0.265	0.105	0.011	0.059	0.471	2.527	0.012
ResCFL_LED Prgm	Cadmus14 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
ResCFL_LED Prgm	Cadmus15 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
ResCFL_LED Prgm	Kema Inc09 2012	ResCFL_LED Prgm	0.598	0.170	0.029	0.264	0.932	3.512	0.000
ResCFL_LED Prgm	Kema10 2012	ResCFL_LED Prgm	0.329	0.247	0.061	-0.155	0.813	1.332	0.183
ResCFL_LED Prgm	Opinion Dynamics et al 2012	ResCFL_LED Prgm	0.111	0.184	0.034	-0.250	0.472	0.602	0.547
ResCFL_LED Prgm	MPSC# U-15885 2011	ResCFL_LED Prgm	0.156	0.202	0.041	-0.241	0.553	0.770	0.441
ResCFL_LED Prgm	MPSC11U-15885 2011	ResCFL_LED Prgm	0.107	0.202	0.041	-0.290	0.504	0.528	0.597
ResCFL_LED Prgm	MPSC# U-16275 2014	ResCFL_LED Prgm	0.239	0.202	0.041	-0.158	0.636	1.180	0.238
ResCFL_LED Prgm	GDSAssociates14 2013	ResCFL_LED Prgm	0.113	0.313	0.098	-0.501	0.727	0.361	0.718
ResCFL_LED Prgm	GDSAssociates15 2013	ResCFL_LED Prgm	0.240	0.313	0.098	-0.374	0.854	0.767	0.443
ResCFL_LED Prgm	CEEnergy[Amended14] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
ResCFL_LED Prgm	CEEnergy[Amended15] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
ResCFL_LED Prgm			0.354	0.048	0.002	0.261	0.448	7.414	0.000
Overall			0.371	0.022	0.000	0.329	0.413	17.194	0.000



Random Effects Model

Figure 4.3. Forest Plot for a Random Effects Model of Programs Effects Size

Table 4.3

Impacts for Overall and Individual Programs

Groups		Effect size and 95% confidence interval					Test of null (2-Tail)		Heterogeneity				Tau-squared			
Group	Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed effect analysis																
CICFL_LED Pgrm	18	0.342	0.030	0.001	0.284	0.400	11.525	0.000	51.587	17.000	0.000	67.046	0.032	0.017	0.000	0.180
CIPres_Cust Prgm	23	0.377	0.025	0.001	0.328	0.427	14.872	0.000	65.810	22.000	0.000	66.570	0.030	0.014	0.000	0.173
EnergyStar Prgm	20	0.410	0.026	0.001	0.358	0.462	15.468	0.000	29.590	19.000	0.057	35.788	0.008	0.007	0.000	0.089
ResCFL_LED Prgm	31	0.352	0.023	0.001	0.308	0.397	15.538	0.000	123.911	30.000	0.000	75.789	0.050	0.018	0.000	0.224
Total within									270.898	88.000	0.000					
Total between									3.816	3.000	0.282					
Overall	92	0.370	0.013	0.000	0.345	0.396	28.825	0.000	274.713	91.000	0.000	66.875	0.031	0.007	0.000	0.175
Mixed effects analysis																
CICFL_LED Pgrm	18	0.319	0.053	0.003	0.216	0.423	6.055	0.000								
CIPres_Cust Prgm	23	0.364	0.045	0.002	0.275	0.453	8.014	0.000								
EnergyStar Prgm	20	0.405	0.034	0.001	0.338	0.471	11.910	0.000								
ResCFL_LED Prgm	31	0.354	0.048	0.002	0.261	0.448	7.414	0.000								
Total within																
Total between									2.090	3.000	0.554					
Overall	92	0.371	0.022	0.000	0.329	0.413	17.194	0.000								

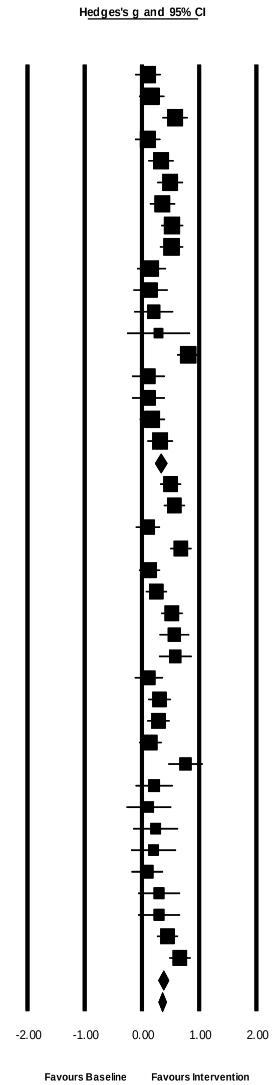
lamp and light emitting diode (CI-CFL_LED Prgm) program, commercial/industrial prescriptive and custom (CI-Prescript_Custom Prgm) program has 0.364 as its value, a value of 0.405 goes to the energy star (EnergyStar Prgm) program and the residential compact fluorescent lamp, and light emitting diode (ResCFL_LED Prgm) program has 0.354 as its value, while the overall summary effect of the programs has 0.370 as the value for the random model. The result shows that EnergyStar Prgm has more impact in energy savings than other programs, followed by the CI-Prescrpt_Custom Prgm, the third and fourth place in the programs energy saving impact goes to ResCFL_LED Prgm and CI-CFL_LED Prgm respectively.

Figure 4.4 and Table 4.4 below is a comparison of CICFL_LED and CIPrescript_Custom programs that confirms the impact in hedge's g of 0.319 and 0.364 respectively for a random effect model. The latter program for the comparison has more impact than the former, while the summary effects size for the two programs is 0.345.

Forest Plot of CICFL_LED Vs CIPrescript_Custom Programs

Group by Subgroup within study	Study name	Subgroup within study	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
CICFL_LED Pgrm	CE Energy 2009	CICFL_LED Pgrm	0.105	0.118	0.014	-0.127	0.337	0.887	0.375
CICFL_LED Pgrm	CE Energy 2010	CICFL_LED Pgrm	0.171	0.118	0.014	-0.061	0.403	1.445	0.148
CICFL_LED Pgrm	CE Energy 2011	CICFL_LED Pgrm	0.578	0.118	0.014	0.346	0.810	4.885	0.000
CICFL_LED Pgrm	CE Energy 2012	CICFL_LED Pgrm	0.101	0.118	0.014	-0.131	0.333	0.854	0.393
CICFL_LED Pgrm	CE Energy 2013	CICFL_LED Pgrm	0.333	0.118	0.014	0.101	0.565	2.814	0.005
CICFL_LED Pgrm	CE Energy 2014	CICFL_LED Pgrm	0.492	0.118	0.014	0.260	0.724	4.158	0.000
CICFL_LED Pgrm	CE Energy 2015	CICFL_LED Pgrm	0.359	0.118	0.014	0.127	0.591	3.034	0.002
CICFL_LED Pgrm	Kema Inc 2012	CICFL_LED Pgrm	0.527	0.105	0.011	0.321	0.733	5.025	0.000
CICFL_LED Pgrm	Kema Inc 2013	CICFL_LED Pgrm	0.517	0.110	0.012	0.302	0.732	4.720	0.000
CICFL_LED Pgrm	DTE Energy 2011	CICFL_LED Pgrm	0.166	0.134	0.018	-0.097	0.429	1.237	0.216
CICFL_LED Pgrm	EMI Consulting 2015	CICFL_LED Pgrm	0.152	0.158	0.025	-0.158	0.462	0.961	0.336
CICFL_LED Pgrm	The Cadmus Inc 2011	CICFL_LED Pgrm	0.207	0.179	0.032	-0.144	0.558	1.157	0.247
CICFL_LED Pgrm	Kema Inc09 2012	CICFL_LED Pgrm	0.291	0.286	0.082	-0.270	0.852	1.016	0.310
CICFL_LED Pgrm	DTE Energy 2012	CICFL_LED Pgrm	0.809	0.105	0.011	0.603	1.015	7.714	0.000
CICFL_LED Pgrm	GDSAssociates14 2013	CICFL_LED Pgrm	0.111	0.152	0.023	-0.186	0.408	0.732	0.464
CICFL_LED Pgrm	GDSAssociates15 2013	CICFL_LED Pgrm	0.113	0.152	0.023	-0.184	0.410	0.745	0.456
CICFL_LED Pgrm	CEEnergy[Amended14] 2013	CICFL_LED Pgrm	0.182	0.118	0.014	-0.050	0.414	1.538	0.124
CICFL_LED Pgrm	CEEnergy[Amended15] 2013	CICFL_LED Pgrm	0.318	0.118	0.014	0.086	0.550	2.688	0.007
CICFL_LED Pgrm			0.319	0.053	0.003	0.216	0.423	6.055	0.000
CIPres_Cust Prgm	CE Energy 2009	CIPres_Cust Prgm	0.500	0.100	0.010	0.304	0.696	5.000	0.000
CIPres_Cust Prgm	CE Energy 2010	CIPres_Cust Prgm	0.566	0.100	0.010	0.370	0.762	5.660	0.000
CIPres_Cust Prgm	CE Energy 2011	CIPres_Cust Prgm	0.103	0.114	0.013	-0.120	0.326	0.903	0.366
CIPres_Cust Prgm	CE Energy 2012	CIPres_Cust Prgm	0.681	0.100	0.010	0.485	0.877	6.810	0.000
CIPres_Cust Prgm	CE Energy 2013	CIPres_Cust Prgm	0.133	0.100	0.010	-0.063	0.329	1.330	0.184
CIPres_Cust Prgm	CE Energy 2014	CIPres_Cust Prgm	0.252	0.100	0.010	0.056	0.448	2.520	0.012
CIPres_Cust Prgm	CE Energy 2015	CIPres_Cust Prgm	0.523	0.100	0.010	0.327	0.719	5.230	0.000
CIPres_Cust Prgm	Kema Inc 2012	CIPres_Cust Prgm	0.566	0.138	0.019	0.296	0.836	4.106	0.000
CIPres_Cust Prgm	Kema Inc 2013	CIPres_Cust Prgm	0.583	0.152	0.023	0.286	0.880	3.844	0.000
CIPres_Cust Prgm	DTE Energy 2011	CIPres_Cust Prgm	0.119	0.130	0.017	-0.137	0.375	0.913	0.361
CIPres_Cust Prgm	DTEEnergy13 2015	CIPres_Cust Prgm	0.307	0.105	0.011	0.101	0.513	2.927	0.003
CIPres_Cust Prgm	DTEEnergy14 2015	CIPres_Cust Prgm	0.287	0.105	0.011	0.081	0.493	2.736	0.006
CIPres_Cust Prgm	DTEEnergy15 2015	CIPres_Cust Prgm	0.148	0.105	0.011	-0.058	0.354	1.411	0.158
CIPres_Cust Prgm	EMI Consulting 2015	CIPres_Cust Prgm	0.761	0.158	0.025	0.451	1.071	4.813	0.000
CIPres_Cust Prgm	KemaIIInc09 2012	CIPres_Cust Prgm	0.213	0.170	0.029	-0.121	0.547	1.251	0.211
CIPres_Cust Prgm	MPSC# U-15885 2011	CIPres_Cust Prgm	0.121	0.205	0.042	-0.281	0.523	0.590	0.555
CIPres_Cust Prgm	MPSC11U-15885 2011	CIPres_Cust Prgm	0.241	0.205	0.042	-0.161	0.643	1.176	0.240
CIPres_Cust Prgm	MPSC# U-16275 2014	CIPres_Cust Prgm	0.202	0.205	0.042	-0.200	0.604	0.986	0.324
CIPres_Cust Prgm	OpinionDynamics Corp. 2012	CIPres_Cust Prgm	0.092	0.145	0.021	-0.192	0.376	0.635	0.526
CIPres_Cust Prgm	GDSAssociates14 2013	CIPres_Cust Prgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
CIPres_Cust Prgm	GDSAssociates15 2013	CIPres_Cust Prgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
CIPres_Cust Prgm	CEEnergy[Amended14] 2013	CIPres_Cust Prgm	0.447	0.100	0.010	0.251	0.643	4.470	0.000
CIPres_Cust Prgm	CEEnergy[Amended15] 2013	CIPres_Cust Prgm	0.664	0.100	0.010	0.468	0.860	6.640	0.000
CIPres_Cust Prgm			0.364	0.045	0.002	0.275	0.453	8.014	0.000
Overall			0.345	0.034	0.001	0.277	0.412	10.024	0.000

Statistics for each study



Random Effects Model

Figure 4.4. Forest Plot for a Random Effects Model of CICFL_LED and CIPrescript_Custom Programs

Table 4.4

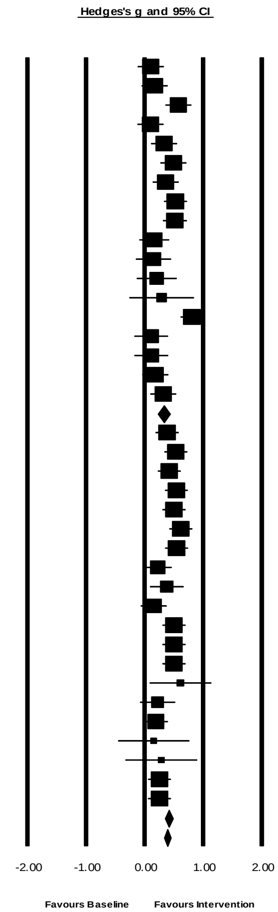
Impacts for a Random Effects Model of CICFL_LED and CIPrescript_Custom Programs

Groups		Effect size and 95% confidence interval					Test of null (2-Tail)		Heterogeneity					Tau-squared			
Group	Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	df (Q)	Tau Squared	Standard Error	Variance	Tau
Fixed effect analysis																	
CICFL_LED Pgrm	18	0.342	0.030	0.001	0.284	0.400	11.525	0.000	51.587	17.000	0.000	67.046	17.000	0.032	0.017	0.000	0.180
CIPres_Cust Prgm	23	0.377	0.025	0.001	0.328	0.427	14.872	0.000	65.810	22.000	0.000	66.570	22.000	0.030	0.014	0.000	0.173
Total within									117.396	39.000	0.000		39.000				
Total between									0.814	1.000	0.367		1.000				
Overall	41	0.363	0.019	0.000	0.325	0.400	18.793	0.000	118.210	40.000	0.000	66.162	40.000	0.030	0.010	0.000	0.173
Mixed effects analysis																	
CICFL_LED Pgrm	18	0.319	0.053	0.003	0.216	0.423	6.055	0.000									
CIPres_Cust Prgm	23	0.364	0.045	0.002	0.275	0.453	8.014	0.000									
Total within																	
Total between									0.407	1.000	0.523		1.000				
Overall	41	0.345	0.034	0.001	0.277	0.412	10.024	0.000									

Figure 4.5 and Table 4.5 below is a comparison of CICFL_LED and EnergyStar programs that confirms the impact in hedge's g of 0.319 and 0.405 respectively for a random effect model. The latter program for the comparison has more impact than the former, while the summary effects size for the two programs is 0.380.

Forest Plot of CICFL_LED Vs EnergyStar Programs

Group by Subgroup within study	Study name	Subgroup within study	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
CICFL_LED Pgrm	CE Energy 2009	CICFL_LED Pgrm	0.105	0.118	0.014	-0.127	0.337	0.887	0.375
CICFL_LED Pgrm	CE Energy 2010	CICFL_LED Pgrm	0.171	0.118	0.014	-0.061	0.403	1.445	0.148
CICFL_LED Pgrm	CE Energy 2011	CICFL_LED Pgrm	0.578	0.118	0.014	0.346	0.810	4.885	0.000
CICFL_LED Pgrm	CE Energy 2012	CICFL_LED Pgrm	0.101	0.118	0.014	-0.131	0.333	0.854	0.393
CICFL_LED Pgrm	CE Energy 2013	CICFL_LED Pgrm	0.333	0.118	0.014	0.101	0.565	2.814	0.005
CICFL_LED Pgrm	CE Energy 2014	CICFL_LED Pgrm	0.492	0.118	0.014	0.260	0.724	4.158	0.000
CICFL_LED Pgrm	CE Energy 2015	CICFL_LED Pgrm	0.359	0.118	0.014	0.127	0.591	3.034	0.002
CICFL_LED Pgrm	Kema Inc 2012	CICFL_LED Pgrm	0.527	0.105	0.011	0.321	0.733	5.025	0.000
CICFL_LED Pgrm	Kema Inc 2013	CICFL_LED Pgrm	0.517	0.110	0.012	0.302	0.732	4.720	0.000
CICFL_LED Pgrm	DTE Energy 2011	CICFL_LED Pgrm	0.166	0.134	0.018	-0.097	0.429	1.237	0.216
CICFL_LED Pgrm	EMI Consulting 2015	CICFL_LED Pgrm	0.152	0.158	0.025	-0.158	0.462	0.961	0.336
CICFL_LED Pgrm	The Cadmus Inc 2011	CICFL_LED Pgrm	0.207	0.179	0.032	-0.144	0.558	1.157	0.247
CICFL_LED Pgrm	Kema Inc09 2012	CICFL_LED Pgrm	0.291	0.286	0.082	-0.270	0.852	1.016	0.310
CICFL_LED Pgrm	DTE Energy 2012	CICFL_LED Pgrm	0.809	0.105	0.011	0.603	1.015	7.714	0.000
CICFL_LED Pgrm	GDSAssociates14 2013	CICFL_LED Pgrm	0.111	0.152	0.023	-0.186	0.408	0.732	0.464
CICFL_LED Pgrm	GDSAssociates15 2013	CICFL_LED Pgrm	0.113	0.152	0.023	-0.184	0.410	0.745	0.456
CICFL_LED Pgrm	CEEnergy[Amended14] 2013	CICFL_LED Pgrm	0.182	0.118	0.014	-0.050	0.414	1.538	0.124
CICFL_LED Pgrm	CEEnergy[Amended15] 2013	CICFL_LED Pgrm	0.318	0.118	0.014	0.086	0.550	2.688	0.007
CICFL_LED Pgrm			0.319	0.053	0.003	0.216	0.423	6.055	0.000
EnergyStar Prgm	CE Energy 2009	EnergyStar Prgm	0.383	0.105	0.011	0.177	0.589	3.652	0.000
EnergyStar Prgm	CE Energy 2010	EnergyStar Prgm	0.533	0.105	0.011	0.327	0.739	5.082	0.000
EnergyStar Prgm	CE Energy 2011	EnergyStar Prgm	0.422	0.105	0.011	0.216	0.628	4.024	0.000
EnergyStar Prgm	CE Energy 2012	EnergyStar Prgm	0.543	0.105	0.011	0.337	0.749	5.177	0.000
EnergyStar Prgm	CE Energy 2013	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	CE Energy 2014	EnergyStar Prgm	0.618	0.105	0.011	0.412	0.824	5.892	0.000
EnergyStar Prgm	CE Energy 2015	EnergyStar Prgm	0.546	0.105	0.011	0.340	0.752	5.206	0.000
EnergyStar Prgm	Kema Inc 2012	EnergyStar Prgm	0.224	0.126	0.016	-0.024	0.472	1.771	0.077
EnergyStar Prgm	Kema Inc 2013	EnergyStar Prgm	0.379	0.152	0.023	0.082	0.676	2.499	0.012
EnergyStar Prgm	DTE Energy 2011	EnergyStar Prgm	0.156	0.118	0.014	-0.076	0.388	1.318	0.187
EnergyStar Prgm	DTEEnergy13 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	DTEEnergy14 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	DTEEnergy15 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	The Cadmus Inc 2015	EnergyStar Prgm	0.613	0.274	0.075	0.076	1.150	2.238	0.025
EnergyStar Prgm	OptimalEnergy Inc. 2013	EnergyStar Prgm	0.222	0.158	0.025	-0.088	0.532	1.404	0.160
EnergyStar Prgm	OpinionDynamics Corp. 2012	EnergyStar Prgm	0.192	0.110	0.012	-0.023	0.407	1.753	0.080
EnergyStar Prgm	GDSAssociates14 2013	EnergyStar Prgm	0.156	0.315	0.099	-0.461	0.773	0.496	0.620
EnergyStar Prgm	GDSAssociates15 2013	EnergyStar Prgm	0.285	0.318	0.101	-0.338	0.908	0.897	0.370
EnergyStar Prgm	CEEnergy[Amended14] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
EnergyStar Prgm	CEEnergy[Amended15] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
EnergyStar Prgm			0.405	0.034	0.001	0.338	0.471	11.910	0.000
Overall			0.380	0.029	0.001	0.324	0.436	13.292	0.000



Random Effects Model

Figure 4.5. Forest Plot for a Random Effects Model of CICFL_LED and EnergyStar Programs

Table 4.5

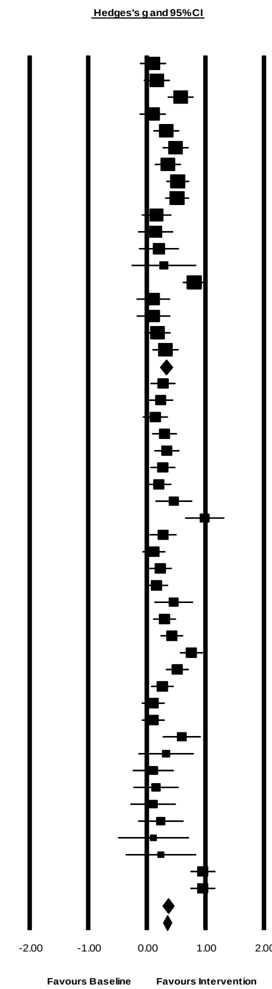
Impacts for a Random Effects Model of CICFL_LED and EnergyStar Programs

Groups		Effect size and 95% confidence interval					Test of null (2-Tail)		Heterogeneity				Tau-squared			
Group	Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed effect analysis																
CICFL_LED Pgrm	18	0.342	0.030	0.001	0.284	0.400	11.525	0.000	51.587	17.000	0.000	67.046	0.032	0.017	0.000	0.180
EnergyStar Prgm	20	0.410	0.026	0.001	0.358	0.462	15.468	0.000	29.590	19.000	0.057	35.788	0.008	0.007	0.000	0.089
Total within									81.177	36.000	0.000					
Total between									2.877	1.000	0.090					
Overall	38	0.380	0.020	0.000	0.341	0.419	19.215	0.000	84.054	37.000	0.000	55.981	0.019	0.008	0.000	0.138
Mixed effects analysis																
CICFL_LED Pgrm	18	0.319	0.053	0.003	0.216	0.423	6.055	0.000								
EnergyStar Prgm	20	0.405	0.034	0.001	0.338	0.471	11.910	0.000								
Total within																
Total between									1.848	1.000	0.174					
Overall	38	0.380	0.029	0.001	0.324	0.436	13.292	0.000								

Figure 4.6 and Table 4.6 below is a comparison of CICFL_LED and ResCFL_LED programs that confirms the impact in hedge’s g of 0.319 and 0.354 respectively for a random effect model. The latter program for the comparison has more impact than the former, while the summary effects size for the two programs is 0.338

Forest Plot of CICFL_LED Vs EnergyStar Programs

Group by / Subgroup within study	Study name	Subgroup within study	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
CICFL_LED Pgrm	CE Energy 2009	CICFL_LED Pgrm	0.105	0.118	0.014	-0.127	0.337	0.887	0.375
CICFL_LED Pgrm	CE Energy 2010	CICFL_LED Pgrm	0.171	0.118	0.014	-0.061	0.403	1.445	0.148
CICFL_LED Pgrm	CE Energy 2011	CICFL_LED Pgrm	0.578	0.118	0.014	0.346	0.810	4.885	0.000
CICFL_LED Pgrm	CE Energy 2012	CICFL_LED Pgrm	0.101	0.118	0.014	-0.131	0.333	0.854	0.393
CICFL_LED Pgrm	CE Energy 2013	CICFL_LED Pgrm	0.333	0.118	0.014	0.101	0.565	2.814	0.005
CICFL_LED Pgrm	CE Energy 2014	CICFL_LED Pgrm	0.492	0.118	0.014	0.260	0.724	4.158	0.000
CICFL_LED Pgrm	CE Energy 2015	CICFL_LED Pgrm	0.359	0.118	0.014	0.127	0.591	3.034	0.002
CICFL_LED Pgrm	Kema Inc 2012	CICFL_LED Pgrm	0.527	0.105	0.011	0.321	0.733	5.025	0.000
CICFL_LED Pgrm	Kema Inc 2013	CICFL_LED Pgrm	0.517	0.110	0.012	0.302	0.732	4.720	0.000
CICFL_LED Pgrm	DTE Energy 2011	CICFL_LED Pgrm	0.166	0.134	0.018	-0.097	0.429	1.237	0.216
CICFL_LED Pgrm	EMI Consulting 2015	CICFL_LED Pgrm	0.152	0.158	0.025	-0.158	0.462	0.961	0.336
CICFL_LED Pgrm	The Cadmus Inc 2011	CICFL_LED Pgrm	0.207	0.179	0.032	-0.144	0.558	1.157	0.247
CICFL_LED Pgrm	Kema Inc09 2012	CICFL_LED Pgrm	0.291	0.286	0.082	-0.270	0.852	1.016	0.310
CICFL_LED Pgrm	DTE Energy 2012	CICFL_LED Pgrm	0.809	0.105	0.011	0.603	1.015	7.714	0.000
CICFL_LED Pgrm	GDSAssociates14 2013	CICFL_LED Pgrm	0.111	0.152	0.023	-0.186	0.408	0.732	0.464
CICFL_LED Pgrm	GDSAssociates15 2013	CICFL_LED Pgrm	0.113	0.152	0.023	-0.184	0.410	0.745	0.456
CICFL_LED Pgrm	CEEnergy[Amended14] 2013	CICFL_LED Pgrm	0.182	0.118	0.014	-0.050	0.414	1.538	0.124
CICFL_LED Pgrm	CEEnergy[Amended15] 2013	CICFL_LED Pgrm	0.318	0.118	0.014	0.086	0.550	2.688	0.007
CICFL_LED Pgrm			0.319	0.053	0.003	0.216	0.423	6.055	0.000
ResCFL_LED Prgm	CE Energy 2009	ResCFL_LED Prgm	0.277	0.114	0.013	0.054	0.500	2.429	0.015
ResCFL_LED Prgm	CE Energy 2010	ResCFL_LED Prgm	0.237	0.114	0.013	0.014	0.460	2.079	0.038
ResCFL_LED Prgm	CE Energy 2011	ResCFL_LED Prgm	0.145	0.114	0.013	-0.078	0.368	1.272	0.203
ResCFL_LED Prgm	CE Energy 2012	ResCFL_LED Prgm	0.302	0.114	0.013	0.079	0.525	2.649	0.008
ResCFL_LED Prgm	CE Energy 2013	ResCFL_LED Prgm	0.342	0.114	0.013	0.119	0.565	3.000	0.003
ResCFL_LED Prgm	CE Energy 2014	ResCFL_LED Prgm	0.273	0.114	0.013	0.050	0.496	2.394	0.017
ResCFL_LED Prgm	CE Energy 2015	ResCFL_LED Prgm	0.204	0.114	0.013	-0.019	0.427	1.789	0.074
ResCFL_LED Prgm	Kema Inc 2012	ResCFL_LED Prgm	0.461	0.164	0.027	0.139	0.783	2.806	0.005
ResCFL_LED Prgm	Kema Inc 2013	ResCFL_LED Prgm	0.988	0.176	0.031	0.643	1.333	5.611	0.000
ResCFL_LED Prgm	DTE Energy 2011	ResCFL_LED Prgm	0.278	0.122	0.015	0.038	0.518	2.270	0.023
ResCFL_LED Prgm	DTEEnergy13 2015	ResCFL_LED Prgm	0.121	0.105	0.011	-0.085	0.327	1.154	0.249
ResCFL_LED Prgm	DTEEnergy14 2015	ResCFL_LED Prgm	0.230	0.105	0.011	0.024	0.436	2.193	0.028
ResCFL_LED Prgm	DTEEnergy15 2015	ResCFL_LED Prgm	0.165	0.105	0.011	-0.041	0.371	1.573	0.116
ResCFL_LED Prgm	The Cadmus Inc 2011	ResCFL_LED Prgm	0.459	0.173	0.030	0.120	0.798	2.650	0.008
ResCFL_LED Prgm	Cadmus09 2014	ResCFL_LED Prgm	0.303	0.105	0.011	0.097	0.509	2.889	0.004
ResCFL_LED Prgm	Cadmus10 2014	ResCFL_LED Prgm	0.427	0.105	0.011	0.221	0.633	4.071	0.000
ResCFL_LED Prgm	Cadmus11 2014	ResCFL_LED Prgm	0.761	0.105	0.011	0.555	0.967	7.256	0.000
ResCFL_LED Prgm	Cadmus12 2014	ResCFL_LED Prgm	0.520	0.105	0.011	0.314	0.726	4.958	0.000
ResCFL_LED Prgm	Cadmus13 2014	ResCFL_LED Prgm	0.265	0.105	0.011	0.059	0.471	2.527	0.012
ResCFL_LED Prgm	Cadmus14 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
ResCFL_LED Prgm	Cadmus15 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
ResCFL_LED Prgm	Kema Inc09 2012	ResCFL_LED Prgm	0.598	0.170	0.029	0.264	0.932	3.512	0.000
ResCFL_LED Prgm	Kema10 2012	ResCFL_LED Prgm	0.329	0.247	0.061	-0.155	0.813	1.332	0.183
ResCFL_LED Prgm	Opinion Dynamics et al 2012	ResCFL_LED Prgm	0.111	0.184	0.034	-0.250	0.472	0.602	0.547
ResCFL_LED Prgm	MPSC# U-15885 2011	ResCFL_LED Prgm	0.156	0.202	0.041	-0.241	0.553	0.770	0.441
ResCFL_LED Prgm	MPSC11U-15885 2011	ResCFL_LED Prgm	0.107	0.202	0.041	-0.290	0.504	0.528	0.597
ResCFL_LED Prgm	MPSC# U-16275 2014	ResCFL_LED Prgm	0.239	0.202	0.041	-0.158	0.636	1.180	0.238
ResCFL_LED Prgm	GDSAssociates14 2013	ResCFL_LED Prgm	0.113	0.313	0.098	-0.501	0.727	0.361	0.718
ResCFL_LED Prgm	GDSAssociates15 2013	ResCFL_LED Prgm	0.240	0.313	0.098	-0.374	0.854	0.767	0.443
ResCFL_LED Prgm	CEEnergy[Amended14] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
ResCFL_LED Prgm	CEEnergy[Amended15] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
ResCFL_LED Prgm			0.354	0.048	0.002	0.261	0.448	7.414	0.000
Overall			0.338	0.035	0.001	0.269	0.408	9.560	0.000



Random Effects Model

Figure 4.6. Forest Plot for a Random Effects Model of CICFL_LED and ResCFL_LED Programs

Table 4.6

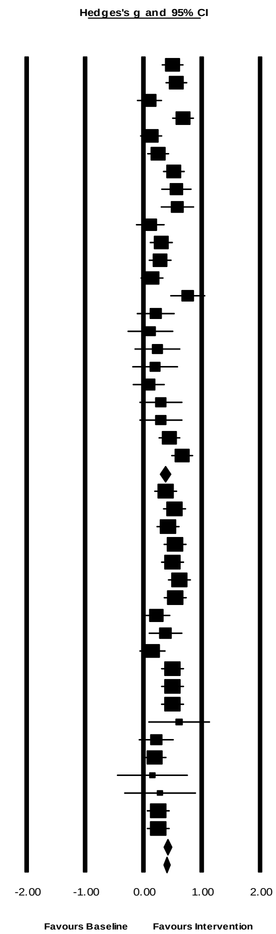
Impacts for a Random Effects Model of CICFL_LED and ResCFL_LED Programs

Groups		Effect size and 95% confidence interval					Test of null (2-Tail)		Heterogeneity				Tau-squared			
Group	Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed effect analysis																
CICFL_LED Pgrm	18	0.342	0.030	0.001	0.284	0.400	11.525	0.000	51.587	17.000	0.000	67.046	0.032	0.017	0.000	0.180
ResCFL_LED Prgm	31	0.352	0.023	0.001	0.308	0.397	15.538	0.000	123.911	30.000	0.000	75.789	0.050	0.018	0.000	0.224
Total within									175.498	47.000	0.000					
Total between									0.073	1.000	0.786					
Overall	49	0.349	0.018	0.000	0.313	0.384	19.344	0.000	175.572	48.000	0.000	72.661	0.042	0.012	0.000	0.206
Mixed effects analysis																
CICFL_LED Pgrm	18	0.319	0.053	0.003	0.216	0.423	6.055	0.000								
ResCFL_LED Prgm	31	0.354	0.048	0.002	0.261	0.448	7.414	0.000								
Total within																
Total between									0.239	1.000	0.625					
Overall	49	0.338	0.035	0.001	0.269	0.408	9.560	0.000								

Figure 4.7 and Table 4.7 below is a comparison of CI-Prescript_Custom and EnergyStar programs that confirms the impact in hedge’s g of 0.364 and 0.405 respectively for a random effect model. The latter program for the comparison has more impact than the former, while the summary effects size for the two programs is 0.390

Forest Plot of CIPrescript_Custom Vs EnergyStar Programs

Group by Subgroup within study	Study name	Subgroup within study	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
CIPres_Cust Prgm	CE Energy 2009	CIPres_Cust Prgm	0.500	0.100	0.010	0.304	0.696	5.000	0.000
CIPres_Cust Prgm	CE Energy 2010	CIPres_Cust Prgm	0.566	0.100	0.010	0.370	0.762	5.660	0.000
CIPres_Cust Prgm	CE Energy 2011	CIPres_Cust Prgm	0.103	0.114	0.013	-0.120	0.326	0.903	0.366
CIPres_Cust Prgm	CE Energy 2012	CIPres_Cust Prgm	0.681	0.100	0.010	0.485	0.877	6.810	0.000
CIPres_Cust Prgm	CE Energy 2013	CIPres_Cust Prgm	0.133	0.100	0.010	-0.063	0.329	1.330	0.184
CIPres_Cust Prgm	CE Energy 2014	CIPres_Cust Prgm	0.252	0.100	0.010	0.056	0.448	2.520	0.012
CIPres_Cust Prgm	CE Energy 2015	CIPres_Cust Prgm	0.523	0.100	0.010	0.327	0.719	5.230	0.000
CIPres_Cust Prgm	Kema Inc 2012	CIPres_Cust Prgm	0.566	0.138	0.019	0.296	0.836	4.106	0.000
CIPres_Cust Prgm	Kema Inc 2013	CIPres_Cust Prgm	0.583	0.152	0.023	0.286	0.880	3.844	0.000
CIPres_Cust Prgm	DTE Energy 2011	CIPres_Cust Prgm	0.119	0.130	0.017	-0.137	0.375	0.913	0.361
CIPres_Cust Prgm	DTEEnergy13 2015	CIPres_Cust Prgm	0.307	0.105	0.011	0.101	0.513	2.927	0.003
CIPres_Cust Prgm	DTEEnergy14 2015	CIPres_Cust Prgm	0.287	0.105	0.011	0.081	0.493	2.736	0.006
CIPres_Cust Prgm	DTEEnergy15 2015	CIPres_Cust Prgm	0.148	0.105	0.011	-0.058	0.354	1.411	0.158
CIPres_Cust Prgm	EMI Consulting 2015	CIPres_Cust Prgm	0.761	0.158	0.025	0.451	1.071	4.813	0.000
CIPres_Cust Prgm	KemaIIInc09 2012	CIPres_Cust Prgm	0.213	0.170	0.029	-0.121	0.547	1.251	0.211
CIPres_Cust Prgm	MPSC# U-15885 2011	CIPres_Cust Prgm	0.121	0.205	0.042	-0.281	0.523	0.590	0.555
CIPres_Cust Prgm	MPSC11U-15885 2011	CIPres_Cust Prgm	0.241	0.205	0.042	-0.161	0.643	1.176	0.240
CIPres_Cust Prgm	MPSC# U-16275 2014	CIPres_Cust Prgm	0.202	0.205	0.042	-0.200	0.604	0.986	0.324
CIPres_Cust Prgm	OpinionDynamics Corp. 2012	CIPres_Cust Prgm	0.092	0.145	0.021	-0.192	0.376	0.635	0.526
CIPres_Cust Prgm	GDSAssociates14 2013	CIPres_Cust Prgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
CIPres_Cust Prgm	GDSAssociates15 2013	CIPres_Cust Prgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
CIPres_Cust Prgm	CEEnergy[Amended14] 2013	CIPres_Cust Prgm	0.447	0.100	0.010	0.251	0.643	4.470	0.000
CIPres_Cust Prgm	CEEnergy[Amended15] 2013	CIPres_Cust Prgm	0.664	0.100	0.010	0.468	0.860	6.640	0.000
CIPres_Cust Prgm			0.364	0.045	0.002	0.275	0.453	8.014	0.000
EnergyStar Prgm	CE Energy 2009	EnergyStar Prgm	0.383	0.105	0.011	0.177	0.589	3.652	0.000
EnergyStar Prgm	CE Energy 2010	EnergyStar Prgm	0.533	0.105	0.011	0.327	0.739	5.082	0.000
EnergyStar Prgm	CE Energy 2011	EnergyStar Prgm	0.422	0.105	0.011	0.216	0.628	4.024	0.000
EnergyStar Prgm	CE Energy 2012	EnergyStar Prgm	0.543	0.105	0.011	0.337	0.749	5.177	0.000
EnergyStar Prgm	CE Energy 2013	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	CE Energy 2014	EnergyStar Prgm	0.618	0.105	0.011	0.412	0.824	5.892	0.000
EnergyStar Prgm	CE Energy 2015	EnergyStar Prgm	0.546	0.105	0.011	0.340	0.752	5.206	0.000
EnergyStar Prgm	Kema Inc 2012	EnergyStar Prgm	0.224	0.126	0.016	-0.024	0.472	1.771	0.077
EnergyStar Prgm	Kema Inc 2013	EnergyStar Prgm	0.379	0.152	0.023	0.082	0.676	2.499	0.012
EnergyStar Prgm	DTE Energy 2011	EnergyStar Prgm	0.156	0.118	0.014	-0.076	0.388	1.318	0.187
EnergyStar Prgm	DTEEnergy13 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	DTEEnergy14 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	DTEEnergy15 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	The Cadmus Inc 2015	EnergyStar Prgm	0.613	0.274	0.075	0.076	1.150	2.238	0.025
EnergyStar Prgm	OptimalEnergy Inc. 2013	EnergyStar Prgm	0.222	0.158	0.025	-0.088	0.532	1.404	0.160
EnergyStar Prgm	OpinionDynamics Corp. 2012	EnergyStar Prgm	0.192	0.110	0.012	-0.023	0.407	1.753	0.080
EnergyStar Prgm	GDSAssociates14 2013	EnergyStar Prgm	0.156	0.315	0.099	-0.461	0.773	0.496	0.620
EnergyStar Prgm	GDSAssociates15 2013	EnergyStar Prgm	0.285	0.318	0.101	-0.338	0.908	0.897	0.370
EnergyStar Prgm	CEEnergy[Amended14] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
EnergyStar Prgm	CEEnergy[Amended15] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
EnergyStar Prgm			0.405	0.034	0.001	0.338	0.471	11.910	0.000
Overall			0.390	0.027	0.001	0.337	0.443	14.337	0.000



Random Effects Model

Figure 4.7. Forest Plot for a Random Effects Model of CIPrescript_Custom and EnergyStar Programs

Table 4.7

Impacts for a Random Effects Model of CIPrescript_Custom and EnergyStar Programs

Groups		Effect size and 95% confidence interval					Test of null (2-Tail)		Heterogeneity				Tau-squared			
Group	Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed effect analysis																
CIPres_Cust Prgm	23	0.377	0.025	0.001	0.328	0.427	14.872	0.000	65.810	22.000	0.000	66.570	0.030	0.014	0.000	0.173
EnergyStar Prgm	20	0.410	0.026	0.001	0.358	0.462	15.468	0.000	29.590	19.000	0.057	35.788	0.008	0.007	0.000	0.089
Total within									95.399	41.000	0.000					
Total between									0.773	1.000	0.379					
Overall	43	0.393	0.018	0.000	0.357	0.429	21.440	0.000	96.173	42.000	0.000	56.329	0.019	0.007	0.000	0.137
Mixed effects analysis																
CIPres_Cust Prgm	23	0.364	0.045	0.002	0.275	0.453	8.014	0.000								
EnergyStar Prgm	20	0.405	0.034	0.001	0.338	0.471	11.910	0.000								
Total within																
Total between									0.520	1.000	0.471					
Overall	43	0.390	0.027	0.001	0.337	0.443	14.337	0.000								

Figure 4.8 and Table 4.8 below is a comparison of CIPrescript_Custom and ResCFL_LED programs that confirms the impact in hedge’s g of 0.364 and 0.354 respectively for a random effect model. The latter program for the comparison has more impact than the former, while the summary effects size for the two programs is 0.359.

Forest Plot of CIPrescript_Custom Vs EnergyStar Programs

Group by Subgroup within study	Study name	Subgroup within study	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
CIPres_CustPrgm	CE Energy 2009	CIPres_CustPrgm	0.500	0.100	0.010	0.304	0.696	5.000	0.000
CIPres_CustPrgm	CE Energy 2010	CIPres_CustPrgm	0.566	0.100	0.010	0.370	0.762	5.660	0.000
CIPres_CustPrgm	CE Energy 2011	CIPres_CustPrgm	0.103	0.114	0.013	-0.120	0.326	0.903	0.366
CIPres_CustPrgm	CE Energy 2012	CIPres_CustPrgm	0.681	0.100	0.010	0.485	0.877	6.810	0.000
CIPres_CustPrgm	CE Energy 2013	CIPres_CustPrgm	0.133	0.100	0.010	-0.063	0.329	1.330	0.184
CIPres_CustPrgm	CE Energy 2014	CIPres_CustPrgm	0.252	0.100	0.010	0.056	0.448	2.520	0.012
CIPres_CustPrgm	CE Energy 2015	CIPres_CustPrgm	0.523	0.100	0.010	0.327	0.719	5.230	0.000
CIPres_CustPrgm	Kema Inc 2012	CIPres_CustPrgm	0.566	0.138	0.019	0.296	0.836	4.106	0.000
CIPres_CustPrgm	Kema Inc 2013	CIPres_CustPrgm	0.583	0.152	0.023	0.286	0.880	3.844	0.000
CIPres_CustPrgm	DTE Energy 2011	CIPres_CustPrgm	0.119	0.130	0.017	-0.137	0.375	0.913	0.361
CIPres_CustPrgm	DTEEnergy13 2015	CIPres_CustPrgm	0.307	0.105	0.011	0.101	0.513	2.927	0.003
CIPres_CustPrgm	DTEEnergy14 2015	CIPres_CustPrgm	0.287	0.105	0.011	0.081	0.493	2.736	0.006
CIPres_CustPrgm	DTEEnergy15 2015	CIPres_CustPrgm	0.148	0.105	0.011	-0.058	0.354	1.411	0.158
CIPres_CustPrgm	EMI Consulting 2015	CIPres_CustPrgm	0.761	0.158	0.025	0.451	1.071	4.813	0.000
CIPres_CustPrgm	KemaIIInc09 2012	CIPres_CustPrgm	0.213	0.170	0.029	-0.121	0.547	1.251	0.211
CIPres_CustPrgm	MPSC# U-15885 2011	CIPres_CustPrgm	0.121	0.205	0.042	-0.281	0.523	0.590	0.555
CIPres_CustPrgm	MPSC11U-15885 2011	CIPres_CustPrgm	0.241	0.205	0.042	-0.161	0.643	1.176	0.240
CIPres_CustPrgm	MPSC# U-16275 2014	CIPres_CustPrgm	0.202	0.205	0.042	-0.200	0.604	0.986	0.324
CIPres_CustPrgm	OpinionDynamics Corp. 2012	CIPres_CustPrgm	0.092	0.145	0.021	-0.192	0.376	0.635	0.526
CIPres_CustPrgm	GDSAssociates14 2013	CIPres_CustPrgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
CIPres_CustPrgm	GDSAssociates15 2013	CIPres_CustPrgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
CIPres_CustPrgm	CEEnergy[Amended14] 2013	CIPres_CustPrgm	0.447	0.100	0.010	0.251	0.643	4.470	0.000
CIPres_CustPrgm	CEEnergy[Amended15] 2013	CIPres_CustPrgm	0.664	0.100	0.010	0.468	0.860	6.640	0.000
CIPres_CustPrgm			0.364	0.045	0.002	0.275	0.453	8.014	0.000
ResCFL_LED Prgm	CE Energy 2009	ResCFL_LED Prgm	0.277	0.114	0.013	0.054	0.500	2.429	0.015
ResCFL_LED Prgm	CE Energy 2010	ResCFL_LED Prgm	0.237	0.114	0.013	0.014	0.460	2.079	0.038
ResCFL_LED Prgm	CE Energy 2011	ResCFL_LED Prgm	0.145	0.114	0.013	-0.078	0.368	1.272	0.203
ResCFL_LED Prgm	CE Energy 2012	ResCFL_LED Prgm	0.302	0.114	0.013	0.079	0.525	2.649	0.008
ResCFL_LED Prgm	CE Energy 2013	ResCFL_LED Prgm	0.342	0.114	0.013	0.119	0.565	3.000	0.003
ResCFL_LED Prgm	CE Energy 2014	ResCFL_LED Prgm	0.273	0.114	0.013	0.050	0.496	2.394	0.017
ResCFL_LED Prgm	CE Energy 2015	ResCFL_LED Prgm	0.204	0.114	0.013	-0.019	0.427	1.789	0.074
ResCFL_LED Prgm	Kema Inc 2012	ResCFL_LED Prgm	0.461	0.164	0.027	0.139	0.783	2.806	0.005
ResCFL_LED Prgm	Kema Inc 2013	ResCFL_LED Prgm	0.988	0.176	0.031	0.643	1.333	5.611	0.000
ResCFL_LED Prgm	DTE Energy 2011	ResCFL_LED Prgm	0.278	0.122	0.015	0.038	0.518	2.270	0.023
ResCFL_LED Prgm	DTEEnergy13 2015	ResCFL_LED Prgm	0.121	0.105	0.011	-0.085	0.327	1.154	0.249
ResCFL_LED Prgm	DTEEnergy14 2015	ResCFL_LED Prgm	0.230	0.105	0.011	0.024	0.436	2.193	0.028
ResCFL_LED Prgm	DTEEnergy15 2015	ResCFL_LED Prgm	0.165	0.105	0.011	-0.041	0.371	1.573	0.116
ResCFL_LED Prgm	The Cadmus Inc 2011	ResCFL_LED Prgm	0.459	0.173	0.030	0.120	0.798	2.650	0.008
ResCFL_LED Prgm	Cadmus09 2014	ResCFL_LED Prgm	0.303	0.105	0.011	0.097	0.509	2.889	0.004
ResCFL_LED Prgm	Cadmus10 2014	ResCFL_LED Prgm	0.427	0.105	0.011	0.221	0.633	4.071	0.000
ResCFL_LED Prgm	Cadmus11 2014	ResCFL_LED Prgm	0.761	0.105	0.011	0.555	0.967	7.256	0.000
ResCFL_LED Prgm	Cadmus12 2014	ResCFL_LED Prgm	0.520	0.105	0.011	0.314	0.726	4.958	0.000
ResCFL_LED Prgm	Cadmus13 2014	ResCFL_LED Prgm	0.265	0.105	0.011	0.059	0.471	2.527	0.012
ResCFL_LED Prgm	Cadmus14 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
ResCFL_LED Prgm	Cadmus15 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
ResCFL_LED Prgm	Kema Inc09 2012	ResCFL_LED Prgm	0.598	0.170	0.029	0.264	0.932	3.512	0.000
ResCFL_LED Prgm	Kema10 2012	ResCFL_LED Prgm	0.329	0.247	0.061	-0.155	0.813	1.332	0.183
ResCFL_LED Prgm	Opinion Dynamics et al 2012	ResCFL_LED Prgm	0.111	0.184	0.034	-0.250	0.472	0.602	0.547
ResCFL_LED Prgm	MPSC# U-15885 2011	ResCFL_LED Prgm	0.156	0.202	0.041	-0.241	0.553	0.770	0.441
ResCFL_LED Prgm	MPSC11U-15885 2011	ResCFL_LED Prgm	0.107	0.202	0.041	-0.290	0.504	0.528	0.597
ResCFL_LED Prgm	MPSC# U-16275 2014	ResCFL_LED Prgm	0.239	0.202	0.041	-0.158	0.636	1.180	0.238
ResCFL_LED Prgm	GDSAssociates14 2013	ResCFL_LED Prgm	0.113	0.313	0.098	-0.501	0.727	0.361	0.718
ResCFL_LED Prgm	GDSAssociates15 2013	ResCFL_LED Prgm	0.240	0.313	0.098	-0.374	0.854	0.767	0.443
ResCFL_LED Prgm	CEEnergy[Amended14] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
ResCFL_LED Prgm	CEEnergy[Amended15] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
ResCFL_LED Prgm			0.354	0.048	0.002	0.261	0.448	7.414	0.000
Overall			0.359	0.033	0.001	0.295	0.424	10.917	0.000

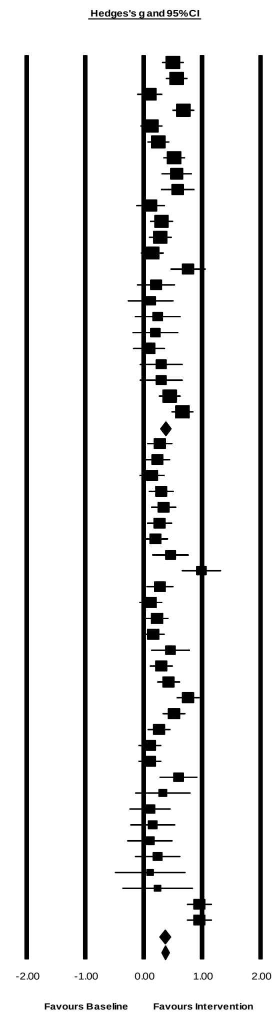


Figure 4.8. Forest Plot for a Random Effects Model of CIPrescript_Custom and ResCFL_LED Programs

Table 4.8

Impacts for a Random Effects Model of CIPrescript_Custom and ResCFL_LED Programs

Groups		Effect size and 95% confidence interval					Test of null (2-Tail)		Heterogeneity				Tau-squared			
Group	Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed effect analysis																
CIPres_Cust Prgm	23	0.377	0.025	0.001	0.328	0.427	14.872	0.000	65.810	22.000	0.000	66.570	0.030	0.014	0.000	0.173
ResCFL_LED Prgm	31	0.352	0.023	0.001	0.308	0.397	15.538	0.000	123.911	30.000	0.000	75.789	0.050	0.018	0.000	0.224
Total within									189.721	52.000	0.000					
Total between									0.545	1.000	0.461					
Overall	54	0.364	0.017	0.000	0.330	0.397	21.496	0.000	190.266	53.000	0.000	72.144	0.040	0.011	0.000	0.200
Mixed effects analysis																
CIPres_Cust Prgm	23	0.364	0.045	0.002	0.275	0.453	8.014	0.000								
ResCFL_LED Prgm	31	0.354	0.048	0.002	0.261	0.448	7.414	0.000								
Total within																
Total between									0.021	1.000	0.884					
Overall	54	0.359	0.033	0.001	0.295	0.424	10.917	0.000								

Figure 4.9 and Table 4.9 below is a comparison of EnergyStar and ResCFL_LED programs that confirms the impact in hedge’s g of 0.405 and 0.354 respectively for a random effect model. The latter program for the comparison has more impact than the former, while the summary effects size for the two programs is 0.388.

Forest Plot of EnergyStar Vs ResCFL_LED Programs

Group by Subgroup within study	Study name	Subgroup within study	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
EnergyStar Prgm	CE Energy 2009	EnergyStar Prgm	0.383	0.105	0.011	0.177	0.589	3.652	0.000
EnergyStar Prgm	CE Energy 2010	EnergyStar Prgm	0.533	0.105	0.011	0.327	0.739	5.082	0.000
EnergyStar Prgm	CE Energy 2011	EnergyStar Prgm	0.422	0.105	0.011	0.216	0.628	4.024	0.000
EnergyStar Prgm	CE Energy 2012	EnergyStar Prgm	0.543	0.105	0.011	0.337	0.749	5.177	0.000
EnergyStar Prgm	CE Energy 2013	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	CE Energy 2014	EnergyStar Prgm	0.618	0.105	0.011	0.412	0.824	5.892	0.000
EnergyStar Prgm	CE Energy 2015	EnergyStar Prgm	0.546	0.105	0.011	0.340	0.752	5.206	0.000
EnergyStar Prgm	Kema Inc 2012	EnergyStar Prgm	0.224	0.126	0.016	-0.024	0.472	1.771	0.077
EnergyStar Prgm	Kema Inc 2013	EnergyStar Prgm	0.379	0.152	0.023	0.082	0.676	2.499	0.012
EnergyStar Prgm	DTE Energy 2011	EnergyStar Prgm	0.156	0.118	0.014	-0.076	0.388	1.318	0.187
EnergyStar Prgm	DTEEnergy13 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	DTEEnergy14 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	DTEEnergy15 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	The Cadmus Inc 2015	EnergyStar Prgm	0.613	0.274	0.075	0.076	1.150	2.238	0.025
EnergyStar Prgm	OptimalEnergy Inc. 2013	EnergyStar Prgm	0.222	0.158	0.025	-0.088	0.532	1.404	0.160
EnergyStar Prgm	OpinionDynamics Corp. 2012	EnergyStar Prgm	0.192	0.110	0.012	-0.023	0.407	1.753	0.080
EnergyStar Prgm	GDSAssociates14 2013	EnergyStar Prgm	0.156	0.315	0.099	-0.461	0.773	0.496	0.620
EnergyStar Prgm	GDSAssociates15 2013	EnergyStar Prgm	0.285	0.318	0.101	-0.338	0.908	0.897	0.370
EnergyStar Prgm	CEEnergy[Amended14]2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
EnergyStar Prgm	CEEnergy[Amended15]2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
EnergyStar Prgm			0.405	0.034	0.001	0.338	0.471	11.910	0.000
ResCFL_LED Prgm	CE Energy 2009	ResCFL_LED Prgm	0.277	0.114	0.013	0.054	0.500	2.429	0.015
ResCFL_LED Prgm	CE Energy 2010	ResCFL_LED Prgm	0.237	0.114	0.013	0.014	0.460	2.079	0.038
ResCFL_LED Prgm	CE Energy 2011	ResCFL_LED Prgm	0.145	0.114	0.013	-0.078	0.368	1.272	0.203
ResCFL_LED Prgm	CE Energy 2012	ResCFL_LED Prgm	0.302	0.114	0.013	0.079	0.525	2.649	0.008
ResCFL_LED Prgm	CE Energy 2013	ResCFL_LED Prgm	0.342	0.114	0.013	0.119	0.565	3.000	0.003
ResCFL_LED Prgm	CE Energy 2014	ResCFL_LED Prgm	0.273	0.114	0.013	0.050	0.496	2.394	0.017
ResCFL_LED Prgm	CE Energy 2015	ResCFL_LED Prgm	0.204	0.114	0.013	-0.019	0.427	1.789	0.074
ResCFL_LED Prgm	Kema Inc 2012	ResCFL_LED Prgm	0.461	0.164	0.027	0.139	0.783	2.806	0.005
ResCFL_LED Prgm	Kema Inc 2013	ResCFL_LED Prgm	0.988	0.176	0.031	0.643	1.333	5.611	0.000
ResCFL_LED Prgm	DTE Energy 2011	ResCFL_LED Prgm	0.278	0.122	0.015	0.038	0.518	2.270	0.023
ResCFL_LED Prgm	DTEEnergy13 2015	ResCFL_LED Prgm	0.121	0.105	0.011	-0.085	0.327	1.154	0.249
ResCFL_LED Prgm	DTEEnergy14 2015	ResCFL_LED Prgm	0.230	0.105	0.011	0.024	0.436	2.193	0.028
ResCFL_LED Prgm	DTEEnergy15 2015	ResCFL_LED Prgm	0.165	0.105	0.011	-0.041	0.371	1.573	0.116
ResCFL_LED Prgm	The Cadmus Inc 2011	ResCFL_LED Prgm	0.459	0.173	0.030	0.120	0.798	2.650	0.008
ResCFL_LED Prgm	Cadmus09 2014	ResCFL_LED Prgm	0.303	0.105	0.011	0.097	0.509	2.889	0.004
ResCFL_LED Prgm	Cadmus10 2014	ResCFL_LED Prgm	0.427	0.105	0.011	0.221	0.633	4.071	0.000
ResCFL_LED Prgm	Cadmus11 2014	ResCFL_LED Prgm	0.761	0.105	0.011	0.555	0.967	7.256	0.000
ResCFL_LED Prgm	Cadmus12 2014	ResCFL_LED Prgm	0.520	0.105	0.011	0.314	0.726	4.958	0.000
ResCFL_LED Prgm	Cadmus13 2014	ResCFL_LED Prgm	0.265	0.105	0.011	0.059	0.471	2.527	0.012
ResCFL_LED Prgm	Cadmus14 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
ResCFL_LED Prgm	Cadmus15 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
ResCFL_LED Prgm	Kema Inc09 2012	ResCFL_LED Prgm	0.598	0.170	0.029	0.264	0.932	3.512	0.000
ResCFL_LED Prgm	Kema10 2012	ResCFL_LED Prgm	0.329	0.247	0.061	-0.155	0.813	1.332	0.183
ResCFL_LED Prgm	Opinion Dynamics etal 2012	ResCFL_LED Prgm	0.111	0.184	0.034	-0.250	0.472	0.602	0.547
ResCFL_LED Prgm	MPSC# U-15885 2011	ResCFL_LED Prgm	0.156	0.202	0.041	-0.241	0.553	0.770	0.441
ResCFL_LED Prgm	MPSC11U-15885 2011	ResCFL_LED Prgm	0.107	0.202	0.041	-0.290	0.504	0.528	0.597
ResCFL_LED Prgm	MPSC# U-16275 2014	ResCFL_LED Prgm	0.239	0.202	0.041	-0.158	0.636	1.180	0.238
ResCFL_LED Prgm	GDSAssociates14 2013	ResCFL_LED Prgm	0.113	0.313	0.098	-0.501	0.727	0.361	0.718
ResCFL_LED Prgm	GDSAssociates15 2013	ResCFL_LED Prgm	0.240	0.313	0.098	-0.374	0.854	0.767	0.443
ResCFL_LED Prgm	CEEnergy[Amended14]2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
ResCFL_LED Prgm	CEEnergy[Amended15]2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
ResCFL_LED Prgm			0.354	0.048	0.002	0.261	0.448	7.414	0.000
Overall			0.388	0.028	0.001	0.333	0.442	14.003	0.000

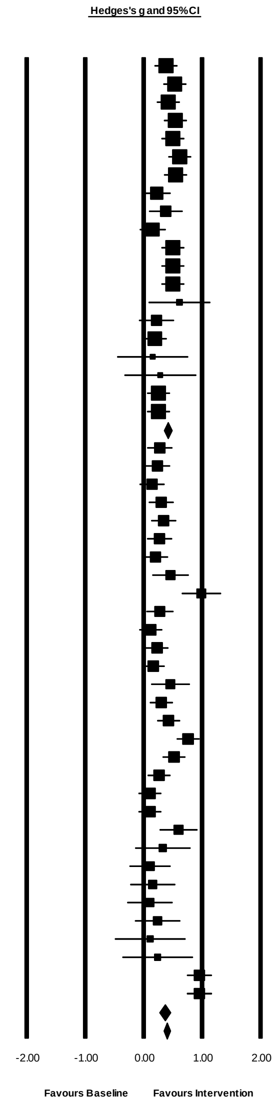


Figure 4.9. Forest Plot for a Random Effects Model of EnergyStar and ResCFL_LED Programs

Table 4.9

Impacts for a Random Effects Model of EnergyStar and ResCFL_LED Programs

Groups		Effect size and 95% confidence interval					Test of null (2-Tail)		Heterogeneity				Tau-squared			
Group	Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed effect analysis																
EnergyStar Prgm	20	0.410	0.026	0.001	0.358	0.462	15.468	0.000	29.590	19.000	0.057	35.788	0.008	0.007	0.000	0.089
ResCFL_LED Prgm	31	0.352	0.023	0.001	0.308	0.397	15.538	0.000	123.911	30.000	0.000	75.789	0.050	0.018	0.000	0.224
Total within									153.501	49.000	0.000					
Total between									2.708	1.000	0.100					
Overall	51	0.377	0.017	0.000	0.343	0.410	21.863	0.000	156.209	50.000	0.000	67.992	0.032	0.010	0.000	0.180
Mixed effects analysis																
EnergyStar Prgm	20	0.405	0.034	0.001	0.338	0.471	11.910	0.000								
ResCFL_LED Prgm	31	0.354	0.048	0.002	0.261	0.448	7.414	0.000								
Total within																
Total between									0.743	1.000	0.389					
Overall	51	0.388	0.028	0.001	0.333	0.442	14.003	0.000								

The EnergyStar program shows not only higher impact on stand alone, but when combined with any other programs. The program shows a greater impact in hedge’s g of 0.405 when compared with the other three programs and also shows an overall higher impact of 0.390 and 0.388 when combined with CIPrescript_Custom and ResCFL_LED programs respectively. In addition, it shows a greater impact 0f 0.380 with CICFL_LED than the other combination of CIPrescript_Custom Vs ResCFL_LED with overall impact of 0.359; CIPrescript_Custom Vs CICFL_LED with overall impact of 0.345 and ResCFL_LED Vs CICFL_LED with overall impact of 0.338.

Investments and Cost-Benefit Ratio for Lighting Programs

The investment with impacts and benefit cost ratio for the program has been displayed as shown in Table 4.10 gives context to the energy savings associated with investment. According to Midwest Energy Efficiency Alliance, 2014 (MEEA) on investment and benefit, any dollar invested in energy saving will yield a benefit of $3.55 as benefit. The programs benefit-cost ratio, except SCT shows a ratio above unity, indicating that the benefit outweighs the cost for each of the programs. This does not necessary reflect the actual situation due to the absence of some investment data in many programs. However, it does give perspective in the assessment of the lighting programs.

Table 4.10

Program Impact Investment and Cost-Benefit Ratios

Programs	Impact	% Rel. Wt.	Cost ($ Million)	Benefit ($ Million)	PACT	TRC	PCT	RIM	SCT
CICFL_LED	0.32	0.249931255156	$567	$2,015	5.5	3.8	8.7	0.5	-
CIPrescript_Custom	0.36	0.250006249531	$449	$1,594	6.4	2.9	5.2	0.6	-
EnergyStar	0.40	0.250056245782	$1,107	$3,931	5.4	2.8	13.1	0.5	-
ResCFL_LED	0.35	0.250006249531	$848	$3,011	6.7	5.4	8.4	0.5	-
Total Cost and Benefit			**$2,972**	**$10,550**					

Greenhouse Gases and Pollutants Emissions

Mean values for energy savings were used to conduct the meta-analysis for a standardized effects size for each of the programs without mention of the overall and each program total energy savings associated with the investment. The eGRID2014 values from EPA used for greenhouse gases (GHG) and pollutant and criteria pollutant emissions are given below. Michigan has total reduced carbon dioxide (CO_2) emissions, a GHG of 2610774.81 tons and criteria pollutants of nitrogen oxides (NO_x) and Sulphur dioxide (SO_2) of 2352.20 tons and 5880.50 tons respectively as shown in Table 4.11 below.

Table 4.11

Greenhouse Gases and Criteria Pollutants Emissions (eGRID2014)

Subregion Emissions-Grenhouse Gases (eGRID2014 Reference)										
			Carbon dioxide (CO_2)		Methane (CH_4)		Nitrous Oxide (N_2O)		Carbon dioxide	
eGRID subregion acronym	eGRID subregion Name	Net generation	Emissions (tons)	Total output emission rate (lb/MWh)	Emissions (lbs)	Total output emission rate (lb/GWh)	Emissions (lbs)	Total output emission rate (lb/GWh)	Emissions (tons)	Total output emission rate (lb/MWh)
RFCM	RFC Michigan	84683436.00	65795773	1553.9	14486516	171.1	2081552	24.6	66270522	1565.1
Subregion Emissions - Criteria Pollutants (eGRID2014)										
			Nitrogen oxides (Nox)				Sulphur dioxide (SO_2)			
			Annual		Ozone Season					
eGRID subregion acronym	eGRID subregion Name		Emissions (tons)	Total output emission rate (lb/MWh)	Emissions (lbs)	Total output emission rate (lb/MWh)	Emissions (lbs)	Total output emission rate (lb/MWh)		
RFCM	RFC - Michigan		60056	1.4	26609	1.4	148572	3.5		
		USEPA, eGRID2014, January 2017								
		Carbon dioxide (CO_2)	Carbon dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)	equivalent (CO_2e)	equivalent (CO_2e)			
Name of Programs	Energy Savings (MWh)	(lbs)	(tons)	(lbs)	(lbs)	(lbs)	(tons)			
CICFL_LED	903827.71	1404457878.57	702228.94	240302743023156.00	34549663812797.40	2198117025748.34	1099058512.87			
CIPrescript_Custom	1192097.56	1852400398.48	926200.20	316945708180612.00	45569049802706.40	2899191863667.31	1449595931.83			
EnergyStar	925629.04	1438334965.26	719167.48	246099112555302.00	35383040145297.60	2251138054122.17	1125569027.06			
ResCFL_LED	338732.46	526356369.59	263178.18	90059574837533.40	12948366692012.40	823800354051.57	411900177.03			
Overall Savings and Quantity of Greenhouse Gases	3360286.77	5221549611.90	2610774.81	893407138596603.00	128450120452814.00	8172247297589.38	4086123648.79			
		Criteria Pollutants (eGRID2014 Reference)								
		Nitrogen oxides (Nox)			Sulphur dioxide (SO_2)					
		Annual		Ozone Season						
Name of Programs	Energy Savings (MWh)	(lbs)	(tons)	(lbs)	(lbs)	(tons)				
CICFL_LED	903827.71	1265358.79	632.68	1265358.79	3163396.99	1581.70				
CIPrescript_Custom	1192097.56	1668936.58	834.47	1668936.58	4172341.46	2086.17				
EnergyStar	925629.04	1295880.66	647.94	1295880.66	3239701.64	1619.85				
ResCFL_LED	338732.46	474225.44	237.11	474225.44	1185563.61	592.78				
Overall Savings and Quantity of Pollutants	**3360286.77**	4704401.48	2352.20	4704401.48	11761003.70	5880.50	1 ton = 2,000 lbs			

These criteria pollutants are used to calculate the air quality, health effects and pollutants.

Table 4.12 below gives the energy saving values of the overall and each of the lighting programs in Michigan. The overall energy saving value of 3360286.78 MWh is estimated for the lighting programs that has a value for each of the program as shown above. These values are used to determine the change in air quality between the baseline and new scenario resulting from avoided emission due to energy savings and the estimated change in health effects as a result of change in ambient particulate matter levels.

Table 4.12

Energy Savings for Overall and Individual Programs

Programs	Impact	% Rel. Wt.	Energy Savings (KWh)
CICFL_LED	0.32	0.25	839840673
CIPrescript_Custom	0.36	0.25	840092675
EnergyStar	0.40	0.25	840260677
ResCFL_LED	0.35	0.25	840092675
Total Energy Savings			**3360286700**

The results of these analysis were carried out using the CO-Benefits Risk Assessment (COBRA) Screening Model, which is developed by EPA for climate protection Partnership divisions, state and local climate and energy programs. The data for conversion for the energy values into tonnage for the GHG and pollutants emissions came from the EPA’s Emissions and Generation Resource Integrated Database (eGRID2014), and created on Jaunary13, 2017.

The energy savings program considered had looked at a statewide change in energy savings, the resultant change in air quality, avoided health effect and the dollar value associated with health impacts. Consequently, air quality, health effects and region maps for the scenario depicted for energy savings are displayed in the tables below. Tables 4.13 air quality and Table 4.14 health effects in all the counties in Michigan are shown below.

The estimated ambient $PM_{2.5}$ concentrations for the lighting programs in Michigan varies from county to counties due to variations in baseline concentration. The estimated ambient $PM_{2.5}$ concentrations in Kalamazoo and Kent counties are 9.587 $\mu g/m^3$ and 8.835 $\mu g/m^3$, compared to their baseline concentration of 9.5 $\mu g/m^3$ and 8.841 $\mu g/m^3$ respectively. The differences between the two counties concentrations is 0.0034 $\mu g/m^3$ and 0.0059 $\mu g/m^3$ respectively. This is the estimated change in air quality due to the reduction of 5880.50 tons of SO_2 and 2352.20 of NO_x from the fuel combustion electricity generating plants due to energy efficiency initiatives (the decrease in emissions from plant due to decrease in energy demand) in Michigan. Positive changes indicate a lower concentration, while negative changes indicate an increase in concentration of criteria pollutants in Michigan.

Table 4.13

Air Quality with Discount Rate of 3%

FIPS	County	State	Control PM 2.5	Base PM 2.5	Delta PM 2.5
26001	Alcona	MI	7.3850	7.3950	0.0099
26003	Alger	MI	5.5370	5.5420	0.0045
26005	Allegan	MI	9.4010	9.4050	0.0038
26007	Alpena	MI	7.0300	7.0380	0.0083
26009	Antrim	MI	7.1960	7.2030	0.0065
26011	Arenac	MI	7.7390	7.7470	0.0075
26013	Baraga	MI	5.3940	5.3960	0.0020
26015	Barry	MI	9.3230	9.3270	0.0045
26017	Bay	MI	7.9490	7.9590	0.0102
26019	Benzie	MI	7.3180	7.3240	0.0056
26021	Berrien	MI	9.7450	9.7480	0.0035
26023	Branch	MI	9.7820	9.7860	0.0038
26025	Calhoun	MI	9.4660	9.4700	0.0041
26027	Cass	MI	10.0750	10.0780	0.0038
26029	Charlevoix	MI	6.8830	6.8890	0.0066
26031	Cheboygan	MI	6.5940	6.6010	0.0069
26033	Chippewa	MI	5.6390	5.6440	0.0049
26035	Clare	MI	7.9500	7.9560	0.0069
26037	Clinton	MI	8.9080	8.9140	0.0057
26039	Crawford	MI	7.6800	7.6880	0.0083
26041	Delta	MI	6.0360	6.0440	0.0082
26043	Dickinson	MI	6.0550	6.0580	0.0031
26045	Eaton	MI	9.2160	9.2220	0.0063
26047	Emmet	MI	6.5200	6.5260	0.0062
26049	Genesee	MI	8.6350	8.6420	0.0073
26051	Gladwin	MI	7.9840	7.9910	0.0071
26053	Gogebic	MI	5.5740	5.5770	0.0026
26055	Grand Traverse	MI	7.4000	7.4060	0.0055
26057	Gratiot	MI	8.6000	8.6070	0.0069
26059	Hillsdale	MI	9.5220	9.5260	0.0045
26061	Houghton	MI	5.1570	5.1590	0.0020
26063	Huron	MI	7.5140	7.5270	0.0122
26065	Ingham	MI	8.8640	8.8690	0.0050
26067	Ionia	MI	9.0860	9.0910	0.0051
26069	Iosco	MI	7.4980	7.5080	0.0097
26071	Iron	MI	5.8180	5.8220	0.0037
26073	Isabella	MI	8.3610	8.3680	0.0069
26075	Jackson	MI	9.3440	9.3480	0.0043
26077	Kalamazoo	MI	9.5870	9.5900	0.0034
26079	Kalkaska	MI	7.6090	7.6160	0.0066
26081	Kent	MI	8.8350	8.8410	0.0059
26083	Keweenaw	MI	4.7030	4.7060	0.0027
26085	Lake	MI	8.1710	8.1780	0.0062
26087	Lapeer	MI	8.6880	8.6960	0.0080
26089	Leelanau	MI	6.9480	6.9540	0.0057
26091	Lenawee	MI	9.4400	9.4450	0.0052
26093	Livingston	MI	8.9350	8.9420	0.0066
26095	Luce	MI	5.4610	5.4660	0.0047
26097	Mackinac	MI	5.9620	5.9680	0.0059
26099	Macomb	MI	9.1960	9.2040	0.0079
26101	Manistee	MI	7.7490	7.7560	0.0073
26103	Marquette	MI	5.5200	5.5290	0.0096
26105	Mason	MI	7.8810	7.8860	0.0049
26107	Mecosta	MI	8.4210	8.4280	0.0069
26109	Menominee	MI	6.4220	6.4260	0.0041
26111	Midland	MI	8.3080	8.3150	0.0070
26113	Missaukee	MI	7.6490	7.6550	0.0067
26115	Monroe	MI	8.7920	8.8040	0.0122
26117	Montcalm	MI	8.7020	8.7090	0.0066
26119	Montmorency	MI	7.2360	7.2440	0.0083
26121	Muskegon	MI	8.6610	8.6680	0.0070
26123	Newaygo	MI	8.5160	8.5220	0.0056
26125	Oakland	MI	9.2800	9.2880	0.0080
26127	Oceana	MI	8.3210	8.3260	0.0052
26129	Ogemaw	MI	7.5500	7.5580	0.0079
26131	Ontonagon	MI	5.3920	5.3940	0.0028
26133	Osceola	MI	7.9830	7.9900	0.0067
26135	Oscoda	MI	7.6120	7.6200	0.0079
26137	Otsego	MI	7.2110	7.2190	0.0074
26139	Ottawa	MI	9.0210	9.0350	0.0136
26141	Presque Isle	MI	6.6100	6.6180	0.0080
26143	Roscommon	MI	7.9230	7.9300	0.0074
26145	Saginaw	MI	8.3150	8.3220	0.0072
26147	St. Clair	MI	9.0460	9.0610	0.0150
26149	St. Joseph	MI	10.0610	10.0650	0.0034
26151	Sanilac	MI	7.8310	7.8440	0.0122
26153	Schoolcraft	MI	5.8060	5.8110	0.0051
26155	Shiawassee	MI	8.7300	8.7370	0.0073
26157	Tuscola	MI	8.0690	8.0770	0.0081
26159	Van Buren	MI	9.6630	9.6670	0.0042
26161	Washtenaw	MI	9.0330	9.0390	0.0052
26163	Wayne	MI	9.1420	9.1560	0.0142
26165	Wexford	MI	7.8340	7.8410	0.0067

Table 4.14

Health Effects with Discount Rate of 3%

State	County	FIPS	($ K) Total Health Effects (low)	($ K) Total Health Effects (high)	Adult Mortality (low)	($ K) Adult Mortality (low)	Adult Mortality (high)	($ K) Adult Mortality (high)	Infant Mortality	($ K) Infant Mortality	Non-fatal Heart Attacks (low)	($ K) Non-fatal Heart Attacks (low)	Non-fatal Heart Attacks (high)	($ K) Non-fatal Heart Attacks (high)	Resp. Hosp. Adm.	($ K) Resp. Hosp. Adm.	CVD Hosp. Adm.	($ K) CVD Hosp. Adm.	Acute Bronchitis	($ K) Acute Bronchitis	Upper Res. Symptoms	($ K) Upper Res. Symptoms	Lower Res. Symptoms	($ K) Lower Res. Symptoms	Asthma ER Visits	($ K) Asthma ER Visits	MRAD	($ K) MRAD	Work Loss Days	($ K) Work Loss Days	Asthma Exacerbations	($ K) Asthma Exacerbations
MI	Alcona	26001	80	179	0.01	79	0.02	178	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.00	0	0.08	0	0.06	0	0.00	0	3.35	0	0.53	0	0.09	0
MI	Alger	26003	28	63	0.00	28	0.01	62	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.04	0	0.03	0	0.00	0	1.48	0	0.24	0	0.04	0
MI	Allegan	26005	180	405	0.02	177	0.05	400	0.00	0	0.00	0	0.02	3	0.00	0	0.01	0	0.04	0	0.64	0	0.45	0	0.01	0	15.83	0	2.62	0	0.66	0
MI	Alpena	26007	147	333	0.02	145	0.04	328	0.00	0	0.00	0	0.03	4	0.00	0	0.01	0	0.02	0	0.27	0	0.19	0	0.01	0	8.39	0	1.38	0	0.29	0
MI	Antrim	26009	83	187	0.01	82	0.02	185	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.18	0	0.12	0	0.00	0	5.13	0	0.83	0	0.18	0
MI	Arenac	26011	76	171	0.01	75	0.02	169	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.13	0	0.09	0	0.00	0	4.00	0	0.65	0	0.13	0
MI	Baraga	26013	9	21	0.00	9	0.00	21	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.02	0	0.01	0	0.00	0	0.62	0	0.10	0	0.02	0
MI	Barry	26015	122	275	0.01	120	0.03	272	0.00	0	0.00	0	0.02	2	0.00	0	0.00	0	0.02	0	0.37	0	0.26	0	0.01	0	9.63	0	1.59	0	0.38	0
MI	Bay	26017	555	1251	0.06	547	0.15	1237	0.00	1	0.01	1	0.07	8	0.02	1	0.04	1	0.07	0	1.32	0	0.92	0	0.03	0	36.99	0	6.14	1	1.37	0
MI	Benzie	26019	49	110	0.01	48	0.01	109	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.12	0	0.08	0	0.00	0	3.35	0	0.55	0	0.12	0
MI	Berrien	26021	275	623	0.03	272	0.07	616	0.00	0	0.00	0	0.03	4	0.01	0	0.01	0	0.04	0	0.68	0	0.48	0	0.01	0	18.22	0	3.02	0	0.71	0
MI	Branch	26023	74	167	0.01	73	0.02	165	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.23	0	0.16	0	0.00	0	6.03	0	1.01	0	0.24	0
MI	Calhoun	26025	265	600	0.03	261	0.07	592	0.00	0	0.00	1	0.04	5	0.01	0	0.01	0	0.04	0	0.73	0	0.51	0	0.01	0	19.04	0	3.17	1	0.77	0
MI	Cass	26027	92	208	0.01	91	0.02	206	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.26	0	0.18	0	0.01	0	7.04	0	1.16	0	0.28	0
MI	Charlevoix	26029	89	200	0.01	88	0.02	198	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.21	0	0.15	0	0.00	0	6.17	0	1.01	0	0.22	0
MI	Cheboygan	26031	102	230	0.01	101	0.03	227	0.00	0	0.00	0	0.01	2	0.00	0	0.00	0	0.01	0	0.20	0	0.14	0	0.00	0	6.29	0	1.03	0	0.21	0
MI	Chippewa	26033	74	168	0.01	73	0.02	166	0.00	0	0.00	0	0.01	2	0.00	0	0.00	0	0.01	0	0.21	0	0.14	0	0.00	0	6.93	0	1.16	0	0.22	0
MI	Clare	26035	125	282	0.01	123	0.03	278	0.00	0	0.00	0	0.02	3	0.01	0	0.01	0	0.01	0	0.24	0	0.17	0	0.00	0	7.18	0	1.18	0	0.25	0
MI	Clinton	26037	162	367	0.02	159	0.04	362	0.00	0	0.00	0	0.02	2	0.00	0	0.01	0	0.03	0	0.61	0	0.42	0	0.01	0	16.38	0	2.74	0	0.64	0
MI	Crawford	26039	71	160	0.01	70	0.02	158	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.13	0	0.09	0	0.00	0	4.07	0	0.65	0	0.13	0
MI	Delta	26041	159	360	0.02	157	0.04	355	0.00	0	0.00	0	0.02	3	0.00	0	0.00	0	0.02	0	0.36	0	0.25	0	0.01	0	9.98	0	1.64	0	0.37	0
MI	Dickinson	26043	43	98	0.01	43	0.01	97	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.00	0	0.09	0	0.06	0	0.00	0	2.76	0	0.45	0	0.09	0
MI	Eaton	26045	308	694	0.04	303	0.08	685	0.00	1	0.00	1	0.04	5	0.01	0	0.01	1	0.05	0	0.87	0	0.61	0	0.02	0	25.04	0	4.16	1	0.92	0
MI	Emmet	26047	97	219	0.01	96	0.03	216	0.00	0	0.00	0	0.01	2	0.00	0	0.00	0	0.01	0	0.26	0	0.18	0	0.01	0	7.79	0	1.28	0	0.28	0
MI	Genesee	26049	1417	3214	0.17	1394	0.38	3165	0.00	4	0.03	3	0.25	30	0.05	1	0.08	3	0.23	0	4.11	0	2.87	0	0.08	0	106.77	0	17.78	3	4.30	0
MI	Gladwin	26051	113	257	0.01	112	0.03	253	0.00	0	0.00	0	0.02	3	0.01	0	0.01	0	0.01	0	0.20	0	0.14	0	0.00	0	6.02	0	0.98	0	0.22	0
MI	Gogebic	26053	27	61	0.00	27	0.01	60	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.04	0	0.03	0	0.00	0	1.42	0	0.23	0	0.04	0
MI	Grand Traverse	26055	214	483	0.02	211	0.06	476	0.00	0	0.00	0	0.04	4	0.01	0	0.01	0	0.03	0	0.57	0	0.40	0	0.01	0	16.67	0	2.78	0	0.59	0
MI	Gratiot	26057	138	313	0.02	136	0.04	308	0.00	0	0.00	0	0.03	3	0.00	0	0.01	0	0.02	0	0.34	0	0.24	0	0.01	0	10.49	0	1.76	0	0.37	0
MI	Hillsdale	26059	95	215	0.01	94	0.03	212	0.00	0	0.00	0	0.02	2	0.00	0	0.00	0	0.01	0	0.27	0	0.19	0	0.01	0	7.02	0	1.16	0	0.29	0
MI	Houghton	26061	34	77	0.00	34	0.01	77	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01	0	0.09	0	0.07	0	0.00	0	2.60	0	0.43	0	0.11	0
MI	Huron	26063	246	556	0.03	243	0.07	549	0.00	0	0.00	1	0.04	5	0.01	0	0.01	0	0.02	0	0.43	0	0.30	0	0.01	0	12.99	0	2.11	0	0.46	0
MI	Ingham	26065	481	1088	0.06	472	0.13	1073	0.00	1	0.01	1	0.06	8	0.02	0	0.02	1	0.09	0	1.58	0	1.11	0	0.04	0	52.84	0	8.94	1	1.83	0
MI	Ionia	26067	118	267	0.01	116	0.03	264	0.00	0	0.00	0	0.02	2	0.00	0	0.01	0	0.02	0	0.45	0	0.31	0	0.01	0	12.56	0	2.10	0	0.47	0
MI	Iosco	26069	194	438	0.02	192	0.05	434	0.00	0	0.00	0	0.03	3	0.01	0	0.01	0	0.01	0	0.21	0	0.15	0	0.00	0	7.69	0	1.24	0	0.22	0
MI	Iron	26071	35	79	0.00	35	0.01	78	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.04	0	0.03	0	0.00	0	1.33	0	0.22	0	0.04	0
MI	Isabella	26073	156	356	0.02	153	0.04	350	0.00	0	0.00	0	0.03	4	0.01	0	0.01	0	0.03	0	0.52	0	0.36	0	0.01	0	18.52	0	3.13	0	0.69	0
MI	Jackson	26075	329	745	0.04	325	0.09	735	0.00	1	0.01	1	0.05	7	0.01	0	0.01	1	0.05	0	0.85	0	0.60	0	0.02	0	24.38	0	4.06	1	0.89	0
MI	Kalamazoo	26077	326	737	0.04	321	0.09	728	0.00	1	0.00	1	0.04	5	0.01	0	0.01	1	0.06	0	1.07	0	0.75	0	0.02	0	31.78	0	5.35	1	1.19	0
MI	Kalkaska	26079	55	125	0.01	54	0.01	123	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.15	0	0.11	0	0.00	0	4.14	0	0.68	0	0.16	0
MI	Kent	26081	1263	2848	0.15	1241	0.33	2812	0.00	5	0.01	2	0.13	16	0.04	1	0.04	2	0.29	0	5.28	0	3.70	0	0.10	0	135.60	0	22.88	4	5.58	0
MI	Keweenaw	26083	3	7	0.00	3	0.00	7	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01	0	0.00	0	0.00	0	0.17	0	0.03	0	0.01	0
MI	Lake	26085	50	112	0.01	49	0.01	111	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.00	0	0.07	0	0.05	0	0.00	0	2.35	0	0.38	0	0.08	0
MI	Lapeer	26087	308	697	0.04	304	0.08	685	0.00	0	0.01	1	0.06	8	0.01	0	0.01	1	0.05	0	0.91	0	0.63	0	0.02	0	26.42	0	4.32	1	0.97	0
MI	Leelanau	26089	76	171	0.01	75	0.02	169	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.13	0	0.09	0	0.00	0	4.00	0	0.64	0	0.14	0
MI	Lenawee	26091	227	512	0.03	224	0.06	506	0.00	0	0.00	0	0.03	3	0.01	0	0.01	0	0.03	0	0.64	0	0.44	0	0.01	0	18.33	0	3.05	0	0.68	0
MI	Livingston	26093	483	1091	0.06	476	0.13	1076	0.00	1	0.01	1	0.07	9	0.01	0	0.02	1	0.09	0	1.69	0	1.18	0	0.03	0	46.44	0	7.60	1	1.80	0
MI	Luce	26095	17	39	0.00	17	0.00	38	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.03	0	0.02	0	0.00	0	1.11	0	0.19	0	0.03	0
MI	Mackinac	26097	39	89	0.00	39	0.01	88	0.00	0	0.00	0	0.00	1	0.00	0	0.00	0	0.00	0	0.07	0	0.05	0	0.00	0	2.15	0	0.35	0	0.07	0
MI	Macomb	26099	2952	6671	0.34	2910	0.78	6584	0.00	5	0.04	5	0.41	50	0.10	3	0.14	5	0.43	0	7.92	0	5.53	0	0.17	0	240.64	0	40.11	6	8.41	0
MI	Manistee	26101	97	220	0.01	96	0.03	217	0.00	0	0.00	0	0.02	2	0.00	0	0.00	0	0.01	0	0.18	0	0.13	0	0.00	0	5.98	0	0.98	0	0.19	0
MI	Marquette	26103	312	706	0.04	309	0.08	699	0.00	0	0.00	0	0.03	4	0.01	0	0.01	0	0.04	0	0.66	0	0.47	0	0.02	0	22.93	0	3.84	1	0.72	0
MI	Mason	26105	74	168	0.01	73	0.02	166	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.17	0	0.12	0	0.00	0	4.72	0	0.77	0	0.18	0
MI	Mecosta	26107	123	279	0.01	121	0.03	275	0.00	0	0.00	0	0.02	2	0.00	0	0.00	0	0.02	0	0.35	0	0.25	0	0.01	0	10.47	0	1.75	0	0.41	0
MI	Menominee	26109	53	119	0.01	52	0.01	118	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.11	0	0.07	0	0.00	0	3.35	0	0.54	0	0.11	0
MI	Midland	26111	242	548	0.03	238	0.06	539	0.00	0	0.01	1	0.05	6	0.01	0	0.01	0	0.04	0	0.73	0	0.51	0	0.01	0	20.44	0	3.38	1	0.77	0
MI	Missaukee	26113	49	111	0.01	49	0.01	110	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.01	0	0.14	0	0.10	0	0.00	0	3.54	0	0.58	0	0.14	0
MI	Monroe	26115	821	1860	0.10	810	0.22	1838	0.00	1	0.01	1	0.10	12	0.02	1	0.02	1	0.13	0	2.45	0	1.71	0	0.05	0	68.47	0	11.32	2	2.59	0
MI	Montcalm	26117	182	411	0.02	179	0.05	405	0.00	0	0.00	0	0.03	4	0.01	0	0.01	0	0.03	0	0.53	0	0.37	0	0.01	0	15.12	0	2.52	0	0.56	0
MI	Montmorency	26119	57	129	0.01	57	0.02	128	0.00	0	0.00	0	0.01	1	0.00	0	0.00	0	0.00	0	0.08	0	0.05	0	0.00	0	2.64	0	0.43	0	0.08	0
MI	Muskegon	26121	541	-1221	0.06	534	0.14	1208	0.00	1	0.01	1	0.06	7	0.01	0	0.01	1	0.09	0	1.61	0	1.13	0	0.03	0	42.76	0	7.14	1	1.69	0
MI	Newaygo	26123	132	298	0.02	130	0.03	294	0.00	0	0.00	242	0.02	2	0.00	0	0.00	0	0.02	0	0.40	0	0.28	0	0.01	0	10.42	0	1.72	0	0.41	0
MI	Oakland	26125	3766	8510	0.44	3710	1.00	8396	0.00	5	0.06	7022	0.54	65	0.12	3	0.17	6	0.63	0	11.54	0	8.06	0	0.25	0	348.00	0	57.83	9	12.27	1
MI	Oceana	26127	62	140	0.01	61	0.02	138	0.00	0	0.00	101	0.01	1	0.00	0	0.00	0	0.01	0	0.20	0	0.14	0	0.00	0	4.62	0	0.76	0	0.20	0
MI	Ogemaw	26129	126	284	0.01	124	0.03	281	0.00	0	0.00	187	0.01	2	0.00	0	0.01	0	0.01	0	0.18	0	0.12	0	0.00	0	5.71	0	0.93	0	0.18	0
MI	Ontonagon	26131	12	27	0.00	12	0.00	27	0.00	0	0.00	19	0.00	0	0.00	0	0.00	0	0.00	0	0.02	0	0.01	0	0.00	0	0.56	0	0.09	0	0.02	0
MI	Osceola	26133	69	157	0.01	68	0.02	154	0.00	0	0.00	198	0.01	2	0.00	0	0.00	0	0.01	0	0.22	0	0.16	0	0.00	0	5.28	0	0.87	0	0.22	0
MI	Oscoda	26135	44	98	0.01	43	0.01	97	0.00	0	0.00	63	0.00	1	0.00	0	0.00	0	0.00	0	0.08	0	0.06	0	0.00	0	2.23	0	0.36	0	0.08	0
MI	Otsego	26137	84	191	0.01	83	0.02	188	0.00	0	0.00	142	0.01	1	0.00	0	0.00	0	0.01	0	0.24	0	0.16	0	0.00	0	6.45	0	1.06	0	0.24	0
MI	Ottawa	26139	1216	2742	0.14	1194	0.32	2704	0.00	3	0.02	2021	0.15	19	0.03	1	0.04	2	0.30	0	5.56	0	3.88	0	0.11	0	141.30	0	23.71	4	6.07	0
MI	Presque Isle	26141	71	161	0.01	71	0.02	160	0.00	0	0.00	112	0.01	1	0.00	0	0.00	0	0.01	0	0.10	0	0.07	0	0.00	0	3.37	0	0.54	0	0.10	0
MI	Roscommon	26143	138	312	0.02	136	0.04	307	0.00	0	0.00	478	0.04	4	0.00	0	0.01	0	0.01	0	0.16	0	0.11	0	0.00	0	5.86	0	0.94	0	0.17	0
MI	Saginaw	26145	725	1644	0.08	715	0.19	1623	0.00	2	0.01	1364	0.10	13	0.02	1	0.03	1	0.10	0	1.78	0	1.24	0	0.04	0	48.87	0	8.14	1	1.88	0
MI	St. Clair	26147	1155	2610	0.14	1139	0.31	2576	0.00	2	0.02	2201	0.17	20	0.05	1	0.05	2	0.17	0	3.11	0	2.17	0	0.06	0	88.79	0	14.61	2	3.28	0
MI	St. Joseph	26149	97	221	0.01	96	0.03	218	0.00	0	0.00	181	0.01	2	0.00	0	0.00	0	0.02	0	0.31	0	0.21	0	0.01	0	7.12	0	1.19	0	0.31	0
MI	Sanilac	26151	263	594	0.03	259	0.07	586	0.00	0	0.00	563	0.04	5	0.01	0	0.01	0	0.04	0	0.68	0	0.47	0	0.01	0	17.69	0	2.91	0	0.70	0
MI	Schoolcraft	26153	28	63	0.00	28	0.01	62	0.00	0	0.00	38	0.00	0	0.00	0	0.00	0	0.00	0	0.04	0	0.03	0	0.00	0	1.38	0	0.22	0	0.05	0
MI	Shiawassee	26155	224	507	0.03	221	0.06	500	0.00	0	0.00	462	0.03	4	0.01	0	0.01	0	0.04	0	0.66	0	0.46	0	0.01	0	18.09	0	2.99	0	0.70	0
MI	Tuscola	26157	216	490	0.03	213	0.06	483	0.00	0	0.00	545	0.04	5	0.01	0	0.01	0	0.03	0	0.56	0	0.39	0	0.01	0	15.47	0	2.55	0	0.59	0
MI	Van Buren	26159	138	313	0.02	136	0.04	309	0.00	0	0.00	318	0.02	3	0.00	0	0.01	0	0.02	0	0.45	0	0.31	0	0.01	0	11.46	0	1.90	0	0.47	0
MI	Washtenaw	26161	532	1202	0.06	521	0.14	1183	0.00	1	0.01	983	0.08	9	0.02	0	0.02	1	0.11	0	2.06	0	1.44	0	0.05	0	72.51	0	12.19	2	2.45	0
MI	Wayne	26163	11162	25379	1.30	10988	2.96	25001	0.00	28	0.20	24620	1.82	229	0.48	12	0.56	22	1.78	1	32.36	1	22.65	0	0.65	0	873.98	0	146.02	23	34.16	2
MI	Wexford	26165	101	229	0.01	99	0.03	225	0.00	0	0.00	325	0.02	3	0.00	0	0.00	0	0.02	0	0.30	0	0.21	0	0.01	0	7.58	0	1.26	0	0.30	0
Total			$35,576	$80,567	4	$35,048	9	$79,456	0	$72	1	$70,450	5	$655	1	$33	2	$61	6	$3	104	$3	73	$2	2	$1	2923	$0	487	$78	111	$6

Table 4.14 shows the reductions in health effects associated with the decrease in pollutant emissions in Sulphur dioxide and nitrogen oxides and other emissions, with positive values indicating decrease in impacts (rare cases of illness/transience or avoided

economic loss or other forms of illness) in Michigan. In Kalamazoo and Kent counties for instance, the change in pollutants concentrations is associated with total avoided effects that ranges from a low economic value to the nearest millions of about $0.3 to $0.7 million for the former county, and $1.3 to $2.9 million for the latter county. The decrease in pollutants impacts for Michigan gives a low avoided economic value to the nearest millions of about $36 million and high value of about $81 million as shown in the table. The specific health effects are shown in blue text, and their economic values shown in black text on the right of each low and high case. The health effects Table 4.14 displays specific health effects and their economic value that include adult mortality, infant mortality, non-fatal heart attacks, respiratory-related hospitalizations, cardiovascular-related hospitalizations, acute bronchitis, upper respiratory symptoms, lower respiratory symptoms, Asthma-related emergency room visits, minor restricted activity days (MRAD), work loss days and Asthma Exacerbations.

Finally, the CO-Benefits Risk Assessment (COBRA) Screening Model displays results maps that shows results from air quality and health effects tables on a map. The map shown is that of the United States that displays a quantity (Delta $PM_{2.5}$ – particulate matter less than or equal to 2.5 microns in diameter), the change in particulate matter concentration between the baseline and Michigan energy savings program. a darker shade of blue shows a high change in concentration as shown below.

The map of the United States shown in Figure 4 10 shows darker shades over Michigan and the neighboring states. The result of reducing pollutant concentrations in Michigan extend to reducing such pollutants from the states that have borders with Michigan.

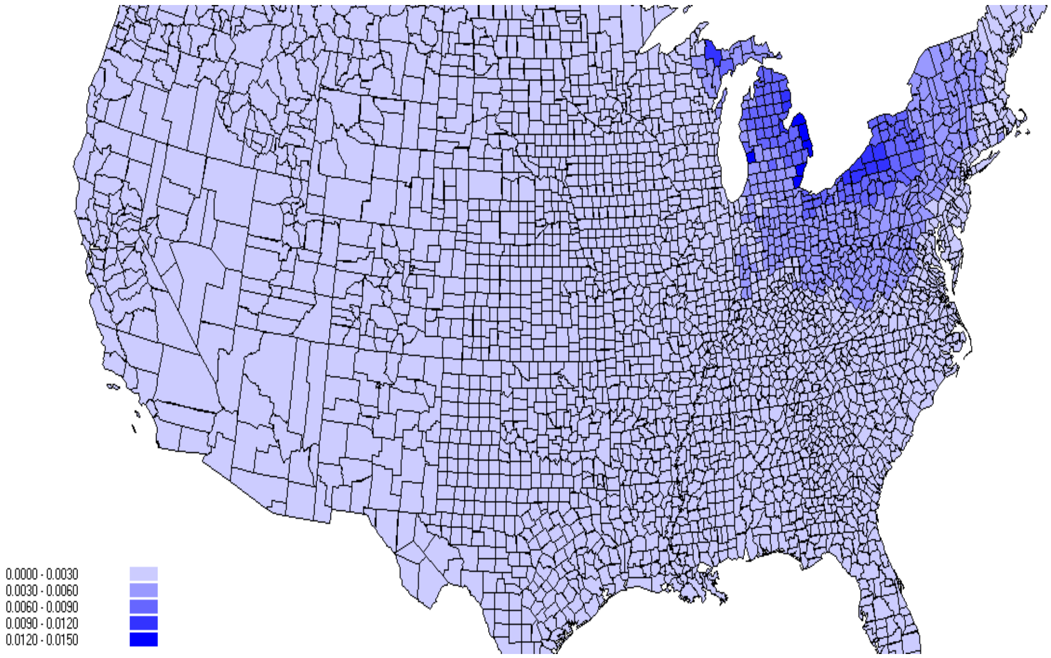


Figure 4.10. COBRA Screening Model Analysis Year 2017 Result Map for Michigan

CHAPTER V

CONCLUSION

This chapter examines the research questions for the study, having presented the result of the evaluation study using meta-analysis as an evaluation method presented in Chapter Four of the dissertation report. The first research and second research questions included are: *In Michigan from 2006 – 2015, using meta-analysis, what is the impact of programs to create energy savings in lighting, and which programs are most cost effective with respect to the investment? What is the total GHG emissions savings from the energy efficiency lighting? Which of the lighting efficiency gives the most GHG emissions saving?* The 92 studies coded and analyzed using meta-analysis software with subgroup as the unit of analysis. This chapter discusses the findings presented in Chapter Four, the impacts of the programs and implications, the contributions of the research to the field of evaluation, and makes a concluding summary statement to the study.

The results of the study revealed that there is an effect in lighting efficiency for the overall lighting programs and individual lighting programs. The overall program effect is 0.360 in Hedges' g with confidence interval of 0.315 to 0.405, a standard error of 0.023 and a p-value of 0.000 for an alpha (α) level of 0.05, which is significant. The 0.360 is above the line of no effect, 0.00, and favors the intervention over the baseline scenario. What this means is that the program is impacted by 0.360, a metric for meta-analysis, a saving in energy of 3.36×10^9 KWh, and putting it in context, gives monetary savings of $11 billion (MEEA, 2014). The monetary savings is in line with the energy efficiency reports developed by the Michigan Energy Office and MPSC in 2011 and released in 2013 that every dollar spent on energy optimization brought a saving of $3.55 to both the utilities and ratepayers.

The Q-statistics gives excess variation of 183.713, with a Q-value of 274.713 and df (Q) value of 91.000, which shows that the studies do not share the same impact as hypothesize by the Q-statistics that the effects are the same, the null hypothesizes is rejected with a p-value of 0.000 at 0.05 level of alpha. The I^2 statistics is 66.875%, a proportion showing the variations in observed impacts that is due to the true impact of the lighting programs. Though, I^2 is reported, but it is a proportion not an absolute term. The true variation in the lighting programs impact (tau-squared) T^2, is 0.031 and the (tau) T, which is the standard deviation is 0.175 giving a prediction interval for the true variation in impact of 0.010 to 0.709. Table 5.1 gives the overall summary, which the effects size of the lighting programs when compared are EnergyStar Prgm with an effects size of 0.40, which is…on energy savings.

Table 5.1

Overall Findings

Overall Findings														
Programs	Impact	% Rel. Wt.	Energy Savings (KWh)	CO_2 (tons)	CO_{2e} (tons)	SO_2 (tons)	Nox (tons	Cost ($ Million)	Benefit ($ Million)	PACT	TRC	PCT	RIM	SCT
CICFL_LED	0.32	0.24993126	839840673	902445	1021250012	1470	588	$567	$2,015	5.5	3.8	8.7	0.5	-
CIPrescript_Custom	0.36	0.25000625	840092675	902716	1021556449	1470	588	$449	$1,594	6.4	2.9	5.2	0.6	-
EnergyStar	0.40	0.25005625	840260677	902897	1021760739	1470	588	$1,107	$3,931	5.4	2.8	13.1	0.5	-
ResCFL_LED	0.35	0.25000625	840092675	902716	1021556449	1470	588	$848	$3,011	6.7	5.4	8.4	0.5	-
Total			**3360286700**	**3610775**	**4086123649**	**5881**	**2352**	**$2,972**	**$10,550**					

Figure 5.1 is the overall summary, which gives the effects size of the lighting programs when compared are EnergyStar Prgm with an effects size of 0.40, which is 8.40260677×10^8 KWh of energy savings, CIPrescript_Custom Prgm effects size is 0.36,

which is 8.40092675 x 10^8 KWh of energy savings, ResCFL_LED Prgm effects size is 0.35, which is 8.40092675 x 10^8 KWh of energy savings, and CICFL_LED Prgm effects size is 0.32, which is 8.39840673 x 10^8 KWh of energy savings for a random effects model. The energy star has a higher effect size (impact) in energy savings, followed by the commercial/industrial prescriptive and custom. Next is the residential compact fluorescent and LED bulb, with the commercial/industrial compact fluorescent and LED programs coming last on effects size on energy savings.

When the lighting programs were combined two at a time for intervention, the combinations of EnergyStar with CIPrescript_Custom gave overall effect size of 0.390 and when EnergyStar combines with ResCFL_LED gave an effect size of 0.388 than the other combinations. In addition, EnergyStar gave a high effect size of 0.380 on energy savings when combined with CICFL_LED program, though higher investment, is the most cost-effective lighting program that impacts the energy savings in Michigan than any of the programs on a single basis or as a combination with another program.

The program with the lowest investment is CIPrescript_Custom program, which ranked second in program effects size, and EnergyStar with the highest investment ranked first in program impact. The CICFL_LED with the second lowest investment ranked fourth in program impact, while the ResCFL_LED with the third lowest investment is also ranked third in Program impact. In addition, the cost-effectiveness test that Michigan uses for energy optimization, the program administrative cost test (PACT) shows that the programs are cost effective. The PACT ensures that the benefits due to consumers are more than the cost associated with payment of bills. These submissions answer the first research question for the study.

The second research question focuses on the emissions of greenhouse gases (GHG) and the emissions of criteria pollutants that reduces the air quality, thereby leading to some health effects in Michigan. The result shows that an overall energy savings of 3.360877×10^9 KWh from the lighting programs reduces 2610774.81 tons of carbon dioxide (CO_2) and 4086123648.79 tons of carbon dioxide equivalent (CO_2e) as GHG. The GHG include carbon dioxide, methane and nitrous oxides, which are simply expressed in a common unit of CO_2e, obtained by the product of the GHG and its global warming potential (GWP). The criteria pollutants avoided by the energy saving include 5880.50 tons of Sulphur dioxide and 2352.20 tons of nitrogen oxides. The improved air quality due to energy savings has health and economic value benefits. The decrease in pollutants impacts Michigan positively, which gives an avoided economic value in health effects in the range of $36 million to $81 million mentioned in Chapter four. It therefore follows that the program with the highest energy saving impact, energy star program for instance may be considered as a priority program to maximize the impact of savings that results in improve air quality and reduction in health impacts.

Discussion

Unpublished data for the research were not available on lighting programs, and some of the lighting programs considered were absent in some studies considered for the research, thereby giving more weight to some studies. In addition, certain studies were discovered, but were narrative in nature, lacking the quantitative values to be include in the study. In addition, some studies failed to include either the investment amount or the benefit-cost ratio values, which serves as test of cost-effectiveness for energy efficiency programs.

Sensitivity analysis showed no difference in the overall impact of the lighting programs in Michigan when studies with high and small effects size in turns were removed from the analysis. In addition, removal of studies with less precision showed no difference in the overall impact for lighting programs in Michigan.

The discount rate of 3% was used to run the COBRA model to reflect interest rate consumers may be entitling to on government backed securities, and favors future benefits to consumers. An interest of 7% reflects opportunity cost to private investors, favoring immediate benefits, thus reducing the economic value of future benefits to such investors (EPA, 2015). The latter result of using higher interest rates will result in higher economic values than using 3% as the discount rate. However, social benefits programs that benefit the society are viewed from a longer term and not purely on immediate economic benefits. Energy efficiency programs interventions are designed for the betterment of society, and a program with a lower interest rate stands to add more value to the quality of life enjoyed by the society than one with a higher interest rate. An assessment of the programs impacts shows that energy star program has more impact than any of the other programs at a higher investment cost. It could be argued that the goal of the programs is to save energy that brings about improvement in air quality, which leads to avoided pollutants and health effects. The wellbeing of the society, and the huge monetary savings might be good reason to continue investment in energy star program as providing more social benefit. It could be that increase investment in other programs with less impact may turn the programs for a huge impact. It is hard to make a conclusive statement in the face of variations in weather effects and natural disasters situations, the failure to record energy saved during such times.

Results and Implications

The implication of the results is the core reason for a meta-analysis on lighting programs in Michigan. The results show that lighting programs have an effect in Michigan, and the impact of these programs vary in their level of impacts. The energy savings lead to reduced amounts of pollutants as the air quality improves, thereby leading reduced health effects and savings on disposable income, which can be channeled to other areas of economic development in the state of Michigan.

The evaluations of energy efficiency programs in Michigan over the years has been given separate energy saving results annually without comparing the programs overtime to see how well a program does by certain measures of energy savings, associated investment amounts, air quality and health implications for embarking on a program versus not embarking, for instance. It also has implications for the type of lighting efficiency program used for energy saving interventions, and not just the dollar value invested, but how well the program would both save energy and reduce the amount of pollutants in the air responsible for health impacts in Michigan. It is imperative that utilities work in tandem with the Environmental Protection Agency to help engagement of the social implications of the program, and not just structuring a program based on engineering analysis that hardly captures the social implication of a program's energy saving.

Contribution of the Research to the Field of Evaluation

The information available on methods for quantifying energy savings from lighting programs have not used meta-analysis as a method of evaluation on lighting programs in Michigan. This study is a pioneer in using the method of meta-analysis in quantifying the impact of energy savings between the periods captured, as well as quantifying the GHG and pollutants avoided and the health implications. To the best of my knowledge, there has been no study that employs the use of comprehensive meta-analysis (CMA) software, CO-Benefits Risk Assessment (COBRA) screening model and eGRID2014 year 2017 to determine the impact of energy savings with respect to the investment, or that determines the economic value of the health effects on a general basis and specific health issues in Michigan. The study adds to the evaluation competences in knowledge, skills, and abilities tempered with attitude to embark on evaluation effectively using the method that bring results to the program beneficially. Hence, an enhanced decision-making and quality judgment of a program is ensured.

Recommendations for Further Research on Lighting Efficiency

There are scant research studies at present on lighting in Michigan, and especially ones that employ meta-analysis as a research method to quantify and determine the effects size (impact) of energy savings on lighting. Lighting efficiency research should employ meta-analysis as a method of evaluation in Michigan where the differences in effect size (impacts) of programs are explored further. Hence, there may be moderating variables like giving one program an incentive than another or providing more rebates that explain the variations in a program's impact, for example. In addition, there should be further research in lighting programs that capture the cumulative savings of specific energy saving lamps, instead of programs over time, for proper utility of such energy saving lamps for energy policy decision-making. Utilities, program administrators, and evaluators should be encouraged to group energy saving values not just on the types of lighting lamps, but on the baseline value of such lamps to help determine the savings from such lamps.

Summary

The disaggregated energy savings from lighting programs are captured with an overall summary effect for the period considered for the programs, and the impacts for the lighting programs differ in Michigan. The more the impact of energy savings from a program, the more the avoided particulate matter concentration, and the more the avoided health impacts in Michigan. The economic value on health-related impact is enormous, and priority should be given to programs that give the most impact in energy savings for at least five years irrespective of the initial investment. The economic impact of the health implications would in the long run be more than triple the initial investment in the energy efficiency of a program that failed to be implemented.

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Appendix A

HSIRB Approval Letter

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: September 21, 2016

To: Ali Metwalli, Principal Investigator
Teryila Ephraim Amough, Student Investigator for dissertation
Stephen Magura, Co-Principal Investigator
Thomas Scannell, Co-Principal Investigator

From: Amy Naugle, Ph.D., Chair

Re: Approval not needed for HSIRB Project Number 16-09-24

This letter will serve as confirmation that your project titled "A Meta-Analysis of Energy Savings from Lighting in Michigan" has been reviewed by the Human Subjects Institutional Review Board (HSIRB). Based on that review, the HSIRB has determined that approval is not required for you to conduct this project because you are not collecting personal identifiable (private) information about individual and your scope of work does not meet the Federal definition of human subject.

45 CFR 46.102 (f) Human Subject

(f) *Human subject* means a living individual **about whom** an investigator (whether professional or student) conducting research obtains

(1) Data through intervention or interaction with the individual, or
(2) Identifiable private information.

Intervention includes both physical procedures by which data are gathered (for example, venipuncture) and manipulations of the subject or the subject's environment that are performed for research purposes. Interaction includes communication or interpersonal contact between investigator and subject. *Private information* includes information about behavior that occurs in a context in which an individual can reasonably expect that no observation or recording is taking place, and information which has been provided for specific purposes by an individual and which the individual can reasonably expect will not be made public (for example, a medical record). Private information must be individually identifiable (i.e., the identity of the subject is or may readily be ascertained by the investigator or associated with the information) in order for obtaining the information to constitute research involving human subjects.

"**About whom**" – a human subject research project requires the data received from the living individual to be about the person.

Thank you for your concerns about protecting the rights and welfare of human subjects.

A copy of your protocol and a copy of this letter will be maintained in the HSIRB files.

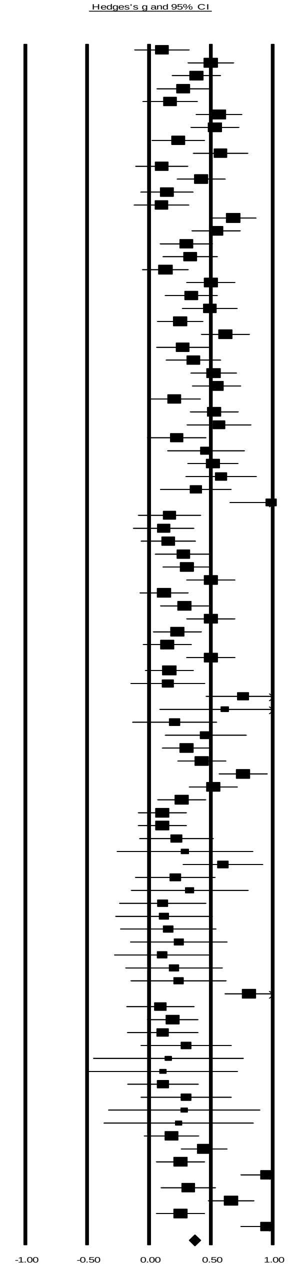
1903 W. Michigan Ave., Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

Appendix B

Forest Plot for Overall Program Impact

Forest Plot for the Overall Program Impact

Study name	Subgroup within study	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
CE Energy 2009	CICFL_LED Pgm	0.105	0.118	0.014	-0.127	0.337	0.887	0.375
CE Energy 2009	CIPres_Cust Prgm	0.500	0.100	0.010	0.304	0.696	5.000	0.000
CE Energy 2009	EnergyStar Prgm	0.383	0.105	0.011	0.177	0.589	3.652	0.000
CE Energy 2009	ResCFL_LED Prgm	0.277	0.114	0.013	0.054	0.500	2.429	0.015
CE Energy 2010	CICFL_LED Pgm	0.171	0.118	0.014	-0.061	0.403	1.445	0.148
CE Energy 2010	CIPres_Cust Prgm	0.566	0.100	0.010	0.370	0.762	5.660	0.000
CE Energy 2010	EnergyStar Prgm	0.533	0.105	0.011	0.327	0.739	5.082	0.000
CE Energy 2010	ResCFL_LED Prgm	0.237	0.114	0.013	0.014	0.460	2.079	0.038
CE Energy 2011	CICFL_LED Pgm	0.578	0.118	0.014	0.346	0.810	4.885	0.000
CE Energy 2011	CIPres_Cust Prgm	0.103	0.114	0.013	-0.120	0.326	0.903	0.366
CE Energy 2011	EnergyStar Prgm	0.422	0.105	0.011	0.216	0.628	4.024	0.000
CE Energy 2011	ResCFL_LED Prgm	0.145	0.114	0.013	-0.078	0.368	1.272	0.203
CE Energy 2012	CICFL_LED Pgm	0.101	0.118	0.014	-0.131	0.333	0.854	0.393
CE Energy 2012	CIPres_Cust Prgm	0.681	0.100	0.010	0.485	0.877	6.810	0.000
CE Energy 2012	EnergyStar Prgm	0.543	0.105	0.011	0.337	0.749	5.177	0.000
CE Energy 2012	ResCFL_LED Prgm	0.302	0.114	0.013	0.079	0.525	2.649	0.008
CE Energy 2013	CICFL_LED Pgm	0.333	0.118	0.014	0.101	0.565	2.814	0.005
CE Energy 2013	CIPres_Cust Prgm	0.133	0.100	0.010	-0.063	0.329	1.330	0.184
CE Energy 2013	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
CE Energy 2013	ResCFL_LED Prgm	0.342	0.114	0.013	0.119	0.565	3.000	0.003
CE Energy 2014	CICFL_LED Pgm	0.492	0.118	0.014	0.260	0.724	4.158	0.000
CE Energy 2014	CIPres_Cust Prgm	0.252	0.100	0.010	0.056	0.448	2.520	0.012
CE Energy 2014	EnergyStar Prgm	0.618	0.105	0.011	0.412	0.824	5.892	0.000
CE Energy 2014	ResCFL_LED Prgm	0.273	0.114	0.013	0.050	0.496	2.394	0.017
CE Energy 2015	CICFL_LED Pgm	0.359	0.118	0.014	0.127	0.591	3.034	0.002
CE Energy 2015	CIPres_Cust Prgm	0.523	0.100	0.010	0.327	0.719	5.230	0.000
CE Energy 2015	EnergyStar Prgm	0.546	0.105	0.011	0.340	0.752	5.206	0.000
CE Energy 2015	ResCFL_LED Prgm	0.204	0.114	0.013	-0.019	0.427	1.789	0.074
Kema Inc 2012	CICFL_LED Pgm	0.527	0.105	0.011	0.321	0.733	5.025	0.000
Kema Inc 2012	CIPres_Cust Prgm	0.566	0.138	0.019	0.296	0.836	4.106	0.000
Kema Inc 2012	EnergyStar Prgm	0.224	0.126	0.016	-0.024	0.472	1.771	0.077
Kema Inc 2012	ResCFL_LED Prgm	0.461	0.164	0.027	0.139	0.783	2.806	0.005
Kema Inc 2013	CICFL_LED Pgm	0.517	0.110	0.012	0.302	0.732	4.720	0.000
Kema Inc 2013	CIPres_Cust Prgm	0.583	0.152	0.023	0.286	0.880	3.844	0.000
Kema Inc 2013	EnergyStar Prgm	0.379	0.152	0.023	0.082	0.676	2.499	0.012
Kema Inc 2013	ResCFL_LED Prgm	0.988	0.176	0.031	0.643	1.333	5.611	0.000
DTE Energy 2011	CICFL_LED Pgm	0.166	0.134	0.018	-0.097	0.429	1.237	0.216
DTE Energy 2011	CIPres_Cust Prgm	0.119	0.130	0.017	-0.137	0.375	0.913	0.361
DTE Energy 2011	EnergyStar Prgm	0.156	0.118	0.014	-0.076	0.388	1.318	0.187
DTE Energy 2011	ResCFL_LED Prgm	0.278	0.122	0.015	0.038	0.518	2.270	0.023
DTEEnergy13 2015	CIPres_Cust Prgm	0.307	0.105	0.011	0.101	0.513	2.927	0.003
DTEEnergy13 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
DTEEnergy13 2015	ResCFL_LED Prgm	0.121	0.105	0.011	-0.085	0.327	1.154	0.249
DTEEnergy14 2015	CIPres_Cust Prgm	0.287	0.105	0.011	0.081	0.493	2.736	0.006
DTEEnergy14 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
DTEEnergy14 2015	ResCFL_LED Prgm	0.230	0.105	0.011	0.024	0.436	2.193	0.028
DTEEnergy15 2015	CIPres_Cust Prgm	0.148	0.105	0.011	-0.058	0.354	1.411	0.158
DTEEnergy15 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
DTEEnergy15 2015	ResCFL_LED Prgm	0.165	0.105	0.011	-0.041	0.371	1.573	0.116
EMI Consulting 2015	CICFL_LED Pgm	0.152	0.158	0.025	-0.158	0.462	0.961	0.336
EMI Consulting 2015	CIPres_Cust Prgm	0.761	0.158	0.025	0.451	1.071	4.813	0.000
The Cadmus Inc 2015	EnergyStar Prgm	0.613	0.274	0.075	0.076	1.150	2.238	0.025
The Cadmus Inc 2011	CICFL_LED Pgm	0.207	0.179	0.032	-0.144	0.558	1.157	0.247
The Cadmus Inc 2011	ResCFL_LED Prgm	0.459	0.173	0.030	0.120	0.798	2.650	0.008
Cadmus09 2014	ResCFL_LED Prgm	0.303	0.105	0.011	0.097	0.509	2.889	0.004
Cadmus10 2014	ResCFL_LED Prgm	0.427	0.105	0.011	0.221	0.633	4.071	0.000
Cadmus11 2014	ResCFL_LED Prgm	0.761	0.105	0.011	0.555	0.967	7.256	0.000
Cadmus12 2014	ResCFL_LED Prgm	0.520	0.105	0.011	0.314	0.726	4.958	0.000
Cadmus13 2014	ResCFL_LED Prgm	0.265	0.105	0.011	0.059	0.471	2.527	0.012
Cadmus14 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
Cadmus15 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
OptimalEnergy Inc. 2013	EnergyStar Prgm	0.222	0.158	0.025	-0.088	0.532	1.404	0.160
Kema Inc09 2012	CICFL_LED Pgm	0.291	0.286	0.082	-0.270	0.852	1.016	0.310
Kema Inc09 2012	ResCFL_LED Prgm	0.598	0.170	0.029	0.264	0.932	3.512	0.000
KemaIIInc09 2012	CIPres_Cust Prgm	0.213	0.170	0.029	-0.121	0.547	1.251	0.211
Kema10 2012	ResCFL_LED Prgm	0.329	0.247	0.061	-0.155	0.813	1.332	0.183
Opinion Dynamics et al 2012	ResCFL_LED Prgm	0.111	0.184	0.034	-0.250	0.472	0.602	0.547
MPSC# U-15885 2011	CIPres_Cust Prgm	0.121	0.205	0.042	-0.281	0.523	0.590	0.555
MPSC# U-15885 2011	ResCFL_LED Prgm	0.156	0.202	0.041	-0.241	0.553	0.770	0.441
MPSC11U-15885 2011	CIPres_Cust Prgm	0.241	0.205	0.042	-0.161	0.643	1.176	0.240
MPSC11U-15885 2011	ResCFL_LED Prgm	0.107	0.202	0.041	-0.290	0.504	0.528	0.597
MPSC# U-16275 2014	CIPres_Cust Prgm	0.202	0.205	0.042	-0.200	0.604	0.986	0.324
MPSC# U-16275 2014	ResCFL_LED Prgm	0.239	0.202	0.041	-0.158	0.636	1.180	0.238
DTE Energy 2012	CICFL_LED Pgm	0.809	0.105	0.011	0.603	1.015	7.714	0.000
OpinionDynamics Corp. 2012	CIPres_Cust Prgm	0.092	0.145	0.021	-0.192	0.376	0.635	0.526
OpinionDynamics Corp. 2012	EnergyStar Prgm	0.192	0.110	0.012	-0.023	0.407	1.753	0.080
GDSAssociates14 2013	CICFL_LED Pgm	0.111	0.152	0.023	-0.186	0.408	0.732	0.464
GDSAssociates14 2013	CIPres_Cust Prgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
GDSAssociates14 2013	EnergyStar Prgm	0.156	0.315	0.099	-0.461	0.773	0.496	0.620
GDSAssociates14 2013	ResCFL_LED Prgm	0.113	0.313	0.098	-0.501	0.727	0.361	0.718
GDSAssociates15 2013	CICFL_LED Pgm	0.113	0.152	0.023	-0.184	0.410	0.745	0.456
GDSAssociates15 2013	CIPres_Cust Prgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
GDSAssociates15 2013	EnergyStar Prgm	0.285	0.318	0.101	-0.338	0.908	0.897	0.370
GDSAssociates15 2013	ResCFL_LED Prgm	0.240	0.313	0.098	-0.374	0.854	0.767	0.443
CEEnergy[Amended14] 2013	CICFL_LED Pgm	0.182	0.118	0.014	-0.050	0.414	1.538	0.124
CEEnergy[Amended14] 2013	CIPres_Cust Prgm	0.447	0.100	0.010	0.251	0.643	4.470	0.000
CEEnergy[Amended14] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
CEEnergy[Amended14] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
CEEnergy[Amended15] 2013	CICFL_LED Pgm	0.318	0.118	0.014	0.086	0.550	2.688	0.007
CEEnergy[Amended15] 2013	CIPres_Cust Prgm	0.664	0.100	0.010	0.468	0.860	6.640	0.000
CEEnergy[Amended15] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
CEEnergy[Amended15] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
		0.360	0.023	0.001	0.315	0.405	15.613	0.000



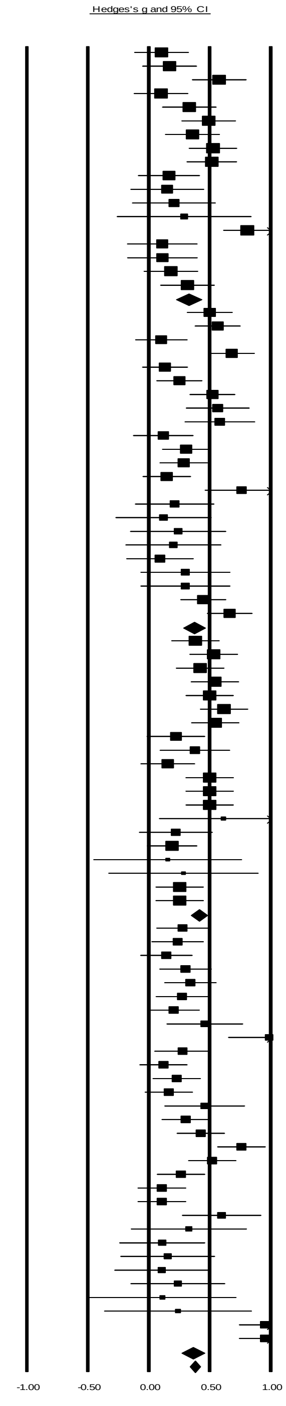
Overall Summary Effects Size for the Lighting Programs in Michigan

Appendix C

Forest Plot for Individual Impacts

Forest Plot for Individual Program Impacts

Group by / Subgroup within study	Study name	Subgroup within study	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
CICFL_LED Pgm	CE Energy 2009	CICFL_LED Pgm	0.105	0.118	0.014	-0.127	0.337	0.887	0.375
CICFL_LED Pgm	CE Energy 2010	CICFL_LED Pgm	0.171	0.118	0.014	-0.061	0.403	1.445	0.148
CICFL_LED Pgm	CE Energy 2011	CICFL_LED Pgm	0.578	0.118	0.014	0.346	0.810	4.885	0.000
CICFL_LED Pgm	CE Energy 2012	CICFL_LED Pgm	0.101	0.118	0.014	-0.131	0.333	0.854	0.393
CICFL_LED Pgm	CE Energy 2013	CICFL_LED Pgm	0.333	0.118	0.014	0.101	0.565	2.814	0.005
CICFL_LED Pgm	CE Energy 2014	CICFL_LED Pgm	0.492	0.118	0.014	0.260	0.724	4.158	0.000
CICFL_LED Pgm	CE Energy 2015	CICFL_LED Pgm	0.359	0.118	0.014	0.127	0.591	3.034	0.002
CICFL_LED Pgm	Kema Inc 2012	CICFL_LED Pgm	0.527	0.105	0.011	0.321	0.733	5.025	0.000
CICFL_LED Pgm	Kema Inc 2013	CICFL_LED Pgm	0.517	0.110	0.012	0.302	0.732	4.720	0.000
CICFL_LED Pgm	DTE Energy 2011	CICFL_LED Pgm	0.166	0.134	0.018	-0.097	0.429	1.237	0.216
CICFL_LED Pgm	EMI Consulting 2015	CICFL_LED Pgm	0.152	0.158	0.025	-0.158	0.462	0.961	0.336
CICFL_LED Pgm	The Cadmus Inc 2011	CICFL_LED Pgm	0.207	0.179	0.032	-0.144	0.558	1.157	0.247
CICFL_LED Pgm	Kema Inc09 2012	CICFL_LED Pgm	0.291	0.286	0.082	-0.270	0.852	1.016	0.310
CICFL_LED Pgm	DTE Energy 2012	CICFL_LED Pgm	0.809	0.105	0.011	0.603	1.015	7.714	0.000
CICFL_LED Pgm	GDSAssociates14 2013	CICFL_LED Pgm	0.111	0.152	0.023	-0.186	0.408	0.732	0.464
CICFL_LED Pgm	GDSAssociates15 2013	CICFL_LED Pgm	0.113	0.152	0.023	-0.184	0.410	0.745	0.456
CICFL_LED Pgm	CEEnergy[Amended14] 2013	CICFL_LED Pgm	0.182	0.118	0.014	-0.050	0.414	1.538	0.124
CICFL_LED Pgm	CEEnergy[Amended15] 2013	CICFL_LED Pgm	0.318	0.118	0.014	0.086	0.550	2.688	0.007
CICFL_LED Pgm			0.319	0.053	0.003	0.216	0.423	6.055	0.000
CIPres_Cust Prgm	CE Energy 2009	CIPres_Cust Prgm	0.500	0.100	0.010	0.304	0.696	5.000	0.000
CIPres_Cust Prgm	CE Energy 2010	CIPres_Cust Prgm	0.566	0.100	0.010	0.370	0.762	5.660	0.000
CIPres_Cust Prgm	CE Energy 2011	CIPres_Cust Prgm	0.103	0.114	0.013	-0.120	0.326	0.903	0.366
CIPres_Cust Prgm	CE Energy 2012	CIPres_Cust Prgm	0.681	0.100	0.010	0.485	0.877	6.810	0.000
CIPres_Cust Prgm	CE Energy 2013	CIPres_Cust Prgm	0.133	0.100	0.010	-0.063	0.329	1.330	0.184
CIPres_Cust Prgm	CE Energy 2014	CIPres_Cust Prgm	0.252	0.100	0.010	0.056	0.448	2.520	0.012
CIPres_Cust Prgm	CE Energy 2015	CIPres_Cust Prgm	0.523	0.100	0.010	0.327	0.719	5.230	0.000
CIPres_Cust Prgm	Kema Inc 2012	CIPres_Cust Prgm	0.566	0.138	0.019	0.296	0.836	4.106	0.000
CIPres_Cust Prgm	Kema Inc 2013	CIPres_Cust Prgm	0.583	0.152	0.023	0.286	0.880	3.844	0.000
CIPres_Cust Prgm	DTE Energy 2011	CIPres_Cust Prgm	0.119	0.130	0.017	-0.137	0.375	0.913	0.361
CIPres_Cust Prgm	DTEEnergy13 2015	CIPres_Cust Prgm	0.307	0.105	0.011	0.101	0.513	2.927	0.003
CIPres_Cust Prgm	DTEEnergy14 2015	CIPres_Cust Prgm	0.287	0.105	0.011	0.081	0.493	2.736	0.006
CIPres_Cust Prgm	DTEEnergy15 2015	CIPres_Cust Prgm	0.148	0.105	0.011	-0.058	0.354	1.411	0.158
CIPres_Cust Prgm	EMI Consulting 2015	CIPres_Cust Prgm	0.761	0.158	0.025	0.451	1.071	4.813	0.000
CIPres_Cust Prgm	KemaIIInc09 2012	CIPres_Cust Prgm	0.213	0.170	0.029	-0.121	0.547	1.251	0.211
CIPres_Cust Prgm	MPSC# U-15885 2011	CIPres_Cust Prgm	0.121	0.205	0.042	-0.281	0.523	0.590	0.555
CIPres_Cust Prgm	MPSC11U-15885 2011	CIPres_Cust Prgm	0.241	0.205	0.042	-0.161	0.643	1.176	0.240
CIPres_Cust Prgm	MPSC# U-16275 2014	CIPres_Cust Prgm	0.202	0.205	0.042	-0.200	0.604	0.986	0.324
CIPres_Cust Prgm	OpinionDynamics Corp. 2012	CIPres_Cust Prgm	0.092	0.145	0.021	-0.192	0.376	0.635	0.526
CIPres_Cust Prgm	GDSAssociates14 2013	CIPres_Cust Prgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
CIPres_Cust Prgm	GDSAssociates15 2013	CIPres_Cust Prgm	0.300	0.192	0.037	-0.077	0.677	1.560	0.119
CIPres_Cust Prgm	CEEnergy[Amended14] 2013	CIPres_Cust Prgm	0.447	0.100	0.010	0.251	0.643	4.470	0.000
CIPres_Cust Prgm	CEEnergy[Amended15] 2013	CIPres_Cust Prgm	0.664	0.100	0.010	0.468	0.860	6.640	0.000
CIPres_Cust Prgm			0.364	0.045	0.002	0.275	0.453	8.014	0.000
EnergyStar Prgm	CE Energy 2009	EnergyStar Prgm	0.383	0.105	0.011	0.177	0.589	3.652	0.000
EnergyStar Prgm	CE Energy 2010	EnergyStar Prgm	0.533	0.105	0.011	0.327	0.739	5.082	0.000
EnergyStar Prgm	CE Energy 2011	EnergyStar Prgm	0.422	0.105	0.011	0.216	0.628	4.024	0.000
EnergyStar Prgm	CE Energy 2012	EnergyStar Prgm	0.543	0.105	0.011	0.337	0.749	5.177	0.000
EnergyStar Prgm	CE Energy 2013	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	CE Energy 2014	EnergyStar Prgm	0.618	0.105	0.011	0.412	0.824	5.892	0.000
EnergyStar Prgm	CE Energy 2015	EnergyStar Prgm	0.546	0.105	0.011	0.340	0.752	5.206	0.000
EnergyStar Prgm	Kema Inc 2012	EnergyStar Prgm	0.224	0.126	0.016	-0.024	0.472	1.771	0.077
EnergyStar Prgm	Kema Inc 2013	EnergyStar Prgm	0.379	0.152	0.023	0.082	0.676	2.499	0.012
EnergyStar Prgm	DTE Energy 2011	EnergyStar Prgm	0.156	0.118	0.014	-0.076	0.388	1.318	0.187
EnergyStar Prgm	DTEEnergy13 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	DTEEnergy14 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	DTEEnergy15 2015	EnergyStar Prgm	0.500	0.105	0.011	0.294	0.706	4.767	0.000
EnergyStar Prgm	The Cadmus Inc 2015	EnergyStar Prgm	0.613	0.274	0.075	0.076	1.150	2.238	0.025
EnergyStar Prgm	OptimalEnergy Inc. 2013	EnergyStar Prgm	0.222	0.158	0.025	-0.088	0.532	1.404	0.160
EnergyStar Prgm	OpinionDynamics Corp. 2012	EnergyStar Prgm	0.192	0.110	0.012	-0.023	0.407	1.753	0.080
EnergyStar Prgm	GDSAssociates14 2013	EnergyStar Prgm	0.156	0.315	0.099	-0.461	0.773	0.496	0.620
EnergyStar Prgm	GDSAssociates15 2013	EnergyStar Prgm	0.285	0.318	0.101	-0.338	0.908	0.897	0.370
EnergyStar Prgm	CEEnergy[Amended14] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
EnergyStar Prgm	CEEnergy[Amended15] 2013	EnergyStar Prgm	0.254	0.105	0.011	0.048	0.460	2.422	0.015
EnergyStar Prgm			0.405	0.034	0.001	0.338	0.471	11.910	0.000
ResCFL_LED Prgm	CE Energy 2009	ResCFL_LED Prgm	0.277	0.114	0.013	0.054	0.500	2.429	0.015
ResCFL_LED Prgm	CE Energy 2010	ResCFL_LED Prgm	0.237	0.114	0.013	0.014	0.460	2.079	0.038
ResCFL_LED Prgm	CE Energy 2011	ResCFL_LED Prgm	0.145	0.114	0.013	-0.078	0.368	1.272	0.203
ResCFL_LED Prgm	CE Energy 2012	ResCFL_LED Prgm	0.302	0.114	0.013	0.079	0.525	2.649	0.008
ResCFL_LED Prgm	CE Energy 2013	ResCFL_LED Prgm	0.342	0.114	0.013	0.119	0.565	3.000	0.003
ResCFL_LED Prgm	CE Energy 2014	ResCFL_LED Prgm	0.273	0.114	0.013	0.050	0.496	2.394	0.017
ResCFL_LED Prgm	CE Energy 2015	ResCFL_LED Prgm	0.204	0.114	0.013	-0.019	0.427	1.789	0.074
ResCFL_LED Prgm	Kema Inc 2012	ResCFL_LED Prgm	0.461	0.164	0.027	0.139	0.783	2.806	0.005
ResCFL_LED Prgm	Kema Inc 2013	ResCFL_LED Prgm	0.988	0.176	0.031	0.643	1.333	5.611	0.000
ResCFL_LED Prgm	DTE Energy 2011	ResCFL_LED Prgm	0.278	0.122	0.015	0.038	0.518	2.270	0.023
ResCFL_LED Prgm	DTEEnergy13 2015	ResCFL_LED Prgm	0.121	0.105	0.011	-0.085	0.327	1.154	0.249
ResCFL_LED Prgm	DTEEnergy14 2015	ResCFL_LED Prgm	0.230	0.105	0.011	0.024	0.436	2.193	0.028
ResCFL_LED Prgm	DTEEnergy15 2015	ResCFL_LED Prgm	0.165	0.105	0.011	-0.041	0.371	1.573	0.116
ResCFL_LED Prgm	The Cadmus Inc 2011	ResCFL_LED Prgm	0.459	0.173	0.030	0.120	0.798	2.650	0.008
ResCFL_LED Prgm	Cadmus09 2014	ResCFL_LED Prgm	0.303	0.105	0.011	0.097	0.509	2.889	0.004
ResCFL_LED Prgm	Cadmus10 2014	ResCFL_LED Prgm	0.427	0.105	0.011	0.221	0.633	4.071	0.000
ResCFL_LED Prgm	Cadmus11 2014	ResCFL_LED Prgm	0.761	0.105	0.011	0.555	0.967	7.256	0.000
ResCFL_LED Prgm	Cadmus12 2014	ResCFL_LED Prgm	0.520	0.105	0.011	0.314	0.726	4.958	0.000
ResCFL_LED Prgm	Cadmus13 2014	ResCFL_LED Prgm	0.265	0.105	0.011	0.059	0.471	2.527	0.012
ResCFL_LED Prgm	Cadmus14 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
ResCFL_LED Prgm	Cadmus15 2014	ResCFL_LED Prgm	0.108	0.105	0.011	-0.098	0.314	1.030	0.303
ResCFL_LED Prgm	Kema Inc09 2012	ResCFL_LED Prgm	0.598	0.170	0.029	0.264	0.932	3.512	0.000
ResCFL_LED Prgm	Kema10 2012	ResCFL_LED Prgm	0.329	0.247	0.061	-0.155	0.813	1.332	0.183
ResCFL_LED Prgm	Opinion Dynamics et al 2012	ResCFL_LED Prgm	0.111	0.184	0.034	-0.250	0.472	0.602	0.547
ResCFL_LED Prgm	MPSC# U-15885 2011	ResCFL_LED Prgm	0.156	0.202	0.041	-0.241	0.553	0.770	0.441
ResCFL_LED Prgm	MPSC11U-15885 2011	ResCFL_LED Prgm	0.107	0.202	0.041	-0.290	0.504	0.528	0.597
ResCFL_LED Prgm	MPSC# U-16275 2014	ResCFL_LED Prgm	0.239	0.202	0.041	-0.158	0.636	1.180	0.238
ResCFL_LED Prgm	GDSAssociates14 2013	ResCFL_LED Prgm	0.113	0.313	0.098	-0.501	0.727	0.361	0.718
ResCFL_LED Prgm	GDSAssociates15 2013	ResCFL_LED Prgm	0.240	0.313	0.098	-0.374	0.854	0.767	0.443
ResCFL_LED Prgm	CEEnergy[Amended14] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
ResCFL_LED Prgm	CEEnergy[Amended15] 2013	ResCFL_LED Prgm	0.955	0.114	0.013	0.732	1.178	8.376	0.000
ResCFL_LED Prgm			0.354	0.048	0.002	0.261	0.448	7.414	0.000
Overall			0.371	0.022	0.000	0.329	0.413	17.194	0.000



Individual Effects Size for the Lighting Programs in Michigan

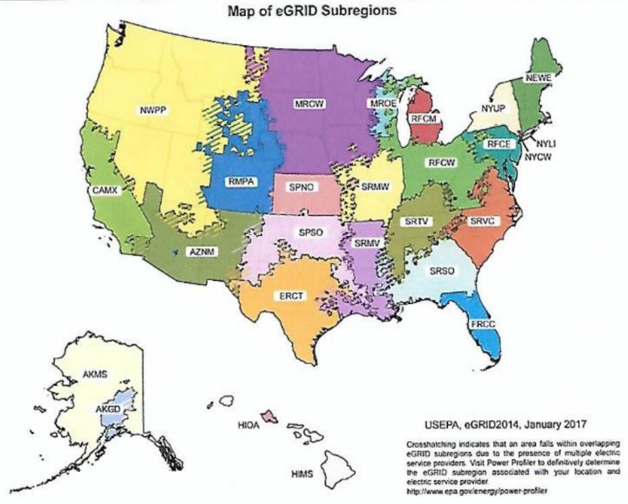
Appendix D

Subregion Emissions – Greenhouse Gases (eGRID2014) Summary Table

1. Subregion Emissions – Greenhouse Gases (eGRID2014)

eGRID subregion acronym	eGRID subregion name	Carbon dioxide (CO_2)		Methane (CH_4)		Nitrous oxide (N_2O)		Carbon dioxide equivalent (CO_2e)	
		Emissions (tons)	Total output emission rate (lb/MWh)	Emissions (lbs)	Total output emission rate (lb/GWh)	Emissions (lbs)	Total output emission rate (lb/GWh)	Emissions (tons)	Total output emission rate (lb/MWh)
AKGD	ASCC Alaska Grid	2,271,327	950.5	235,717	49.3	36,096	7.6	2,279,397	953.9
AKMS	ASCC Miscellaneous	431,829	682.3	46,590	36.8	7,717	6.1	433,514	685.0
AZNM	WECC Southwest	58,722,243	878.5	8,885,668	66.5	1,246,386	9.3	59,008,733	882.8
CAMX	WECC California	58,517,758	619.9	6,937,645	36.7	846,220	4.5	58,708,429	621.9
ERCT	ERCOT All	182,296,859	1,103.2	21,994,474	66.6	3,056,622	9.2	183,000,174	1,107.5
FRCC	FRCC All	119,182,697	1,088.7	19,362,545	88.4	2,656,146	12.1	119,797,706	1,094.3
HIMS	HICC Miscellaneous	1,347,592	946.3	286,274	100.5	45,308	15.9	1,357,621	953.4
HIOA	HICC Oahu	5,948,003	1,617.1	1,289,024	175.2	198,057	26.9	5,992,237	1,629.2
MROE	MRO East	21,264,234	1,267.5	5,059,440	150.8	744,455	22.2	21,432,749	1,277.5
MROW	MRO West	133,211,094	1,248.5	31,672,607	148.4	4,580,399	21.5	134,240,219	1,258.1
NEWE	NPCC New England	32,009,498	578.2	10,854,765	98.0	1,457,118	13.2	32,340,975	584.2
NWPP	WECC Northwest	156,526,173	915.7	33,824,194	98.9	4,918,566	14.4	157,643,705	922.3
NYCW	NPCC NYC/Westchester	13,351,441	699.4	955,968	25.0	116,269	3.0	13,379,501	700.9
NYLI	NPCC Long Island	6,941,550	1,229.1	1,502,503	133.0	194,935	17.3	6,987,541	1,237.3
NYUP	NPCC Upstate NY	15,874,045	377.2	2,719,026	32.3	367,664	4.4	15,959,583	379.2
RFCE	RFC East	115,641,481	852.9	20,491,528	75.6	3,121,875	11.5	116,340,504	858.1
RFCM	RFC Michigan	65,795,773	1,553.9	14,486,516	171.1	2,081,552	24.6	66,270,522	1,565.1
RFCW	RFC West	391,005,851	1,497.1	84,252,343	161.3	12,367,250	23.7	393,807,342	1,507.8
RMPA	WECC Rockies	74,633,546	1,774.0	15,595,812	185.3	2,257,672	26.8	75,147,241	1,786.2
SPNO	SPP North	41,178,975	1,458.6	9,076,955	160.8	1,316,804	23.3	41,478,388	1,469.2
SPSO	SPP South	133,299,588	1,586.3	25,225,795	150.1	3,671,417	21.8	134,133,529	1,596.3
SRMV	SERC Mississippi Valley	107,443,349	1,160.0	16,725,200	90.3	2,400,141	13.0	107,990,986	1,165.9
SRMW	SERC Midwest	152,730,744	1,606.8	35,647,560	187.5	5,183,070	27.3	153,908,419	1,619.2
SRSO	SERC South	153,297,552	1,144.5	28,221,764	105.4	4,189,225	15.6	154,240,455	1,151.6
SRTV	SERC Tennessee Valley	164,450,131	1,368.1	34,172,508	142.1	4,985,828	20.7	165,577,158	1,377.4
SRVC	SERC Virginia/Carolina	124,094,377	862.3	28,696,177	99.7	4,134,405	14.4	125,021,386	868.8
U.S.		**2,331,467,711**	**1,143.0**	**458,218,597**	**112.3**	**66,181,198**	**16.2**	**2,346,478,012**	**1,150.3**

Map of eGRID Subregions



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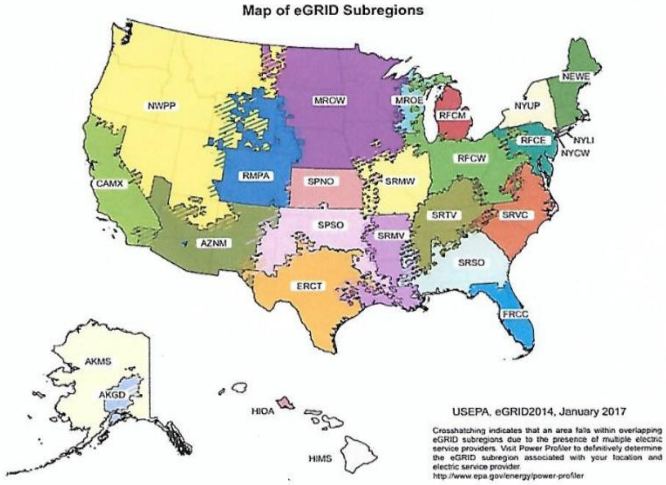
Appendix E

Subregion Emissions – Criteria Pollutants (eGRID2014) Summary Table

2. Subregion Emissions – Criteria Pollutants (eGRID2014)

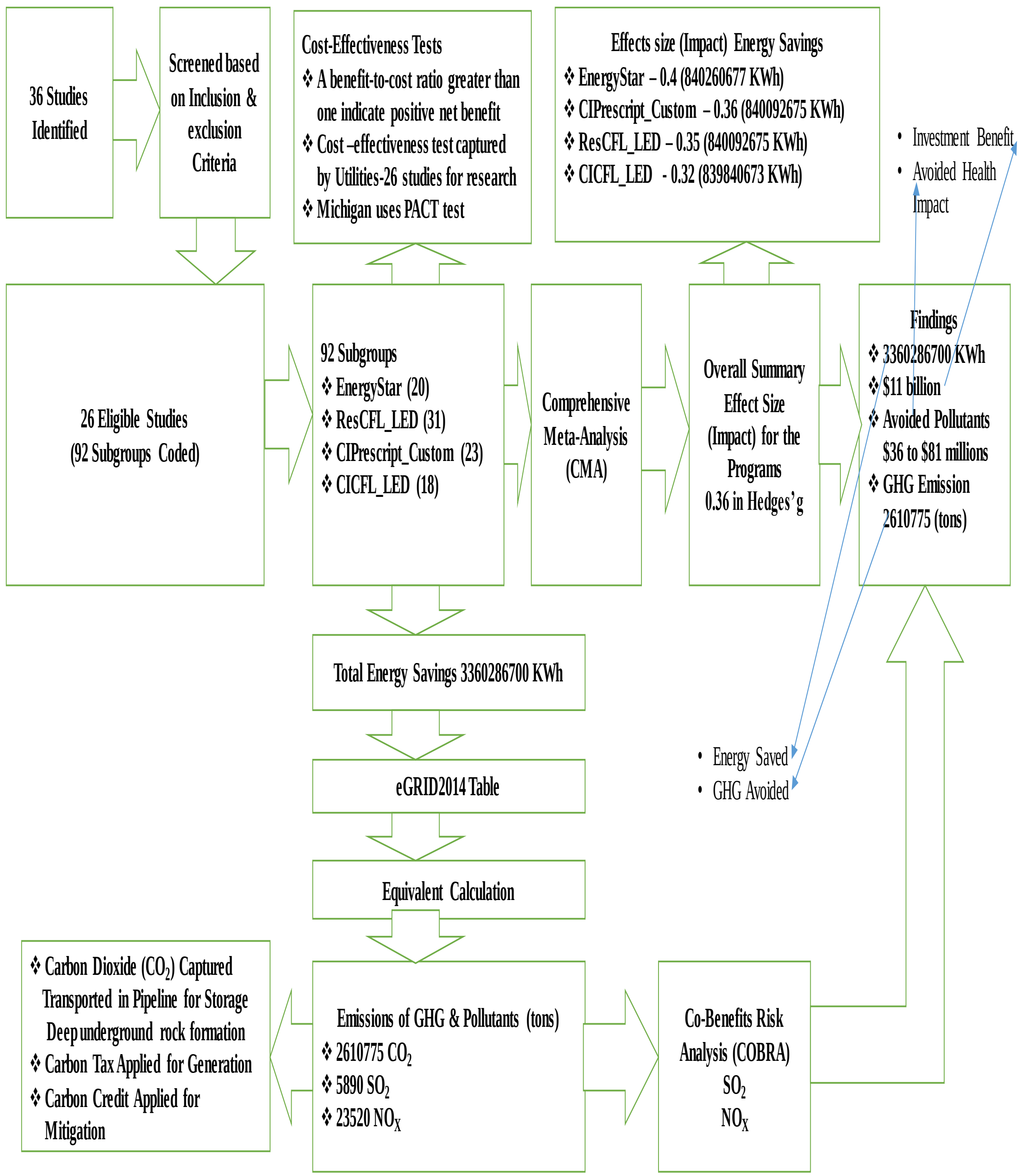
eGRID subregion acronym	eGRID subregion name	Nitrogen oxides (NO_x)				Sulfur dioxide (SO_2)	
		Annual		Ozone Season			
		Emissions (tons)	Total output emission rate (lb/MWh)	Emissions (tons)	Total output emission rate (lb/MWh)	Emissions (tons)	Total output emission rate (lb/MWh)
AKGD	ASCC Alaska Grid	4,919	2.1	2,039	2.2	1,596	0.7
AKMS	ASCC Miscellaneous	6,103	9.6	2,101	8.8	614.724	1.0
AZNM	WECC Southwest	44,154	0.7	20,055	0.6	21,800	0.3
CAMX	WECC California	48,701	0.5	21,833	0.5	3,891	0.0
ERCT	ERCOT All	112,966	0.7	51,780	0.7	212,177	1.3
FRCC	FRCC All	69,228	0.6	31,783	0.6	90,415	0.8
HIMS	HICC Miscellaneous	9,845	6.9	4,474	7.3	5,466	3.8
HIOA	HICC Oahu	12,025	3.3	5,242	3.3	35,633	9.7
MROE	MRO East	17,016	1.0	7,193	1.0	42,349	2.5
MROW	MRO West	143,376	1.3	58,554	1.4	217,659	2.0
NEWE	NPCC New England	26,429	0.5	9,229	0.4	13,337	0.2
NWPP	WECC Northwest	206,134	1.2	88,036	1.2	108,765	0.6
NYCW	NPCC NYC/Westchester	6,135	0.3	2,872	0.3	901.075	0.0
NYLI	NPCC Long Island	5,230	0.9	2,013	0.8	2,547	0.5
NYUP	NPCC Upstate NY	17,504	0.4	5,941	0.3	19,079	0.5
RFCE	RFC East	114,682	0.8	41,480	0.7	263,911	1.9
RFCM	RFC Michigan	60,056	1.4	26,609	1.4	148,572	3.5
RFCW	RFC West	351,300	1.3	141,276	1.3	820,643	3.1
RMPA	WECC Rockies	65,616	1.6	27,511	1.6	64,362	1.5
SPNO	SPP North	32,775	1.2	15,367	1.2	40,185	1.4
SPSO	SPP South	101,918	1.2	46,813	1.2	241,092	2.9
SRMV	SERC Mississippi Valley	92,588	1.0	43,127	1.0	129,833	1.4
SRMW	SERC Midwest	108,113	1.1	43,987	1.1	249,718	2.6
SRSO	SERC South	101,960	0.8	41,305	0.7	268,212	2.0
SRTV	SERC Tennessee Valley	122,535	1.0	49,906	1.0	264,542	2.2
SRVC	SERC Virginia/Carolina	86,316	0.6	35,553	0.6	101,773	0.7
U.S.		**1,967,626**	**1.0**	**826,081**	**0.9**	**3,369,074**	**1.7**

Map of eGRID Subregions



Appendix F

Input – Output Diagram for Energy Savings from Lighting


36 Studies Identified
Screened based on Inclusion & exclusion Criteria
Cost-Effectiveness Tests
❖ A benefit-to-cost ratio greater than one indicate positive net benefit
❖ Cost –effectiveness test captured by Utilities-26 studies for research
❖ Michigan uses PACT test
Effects size (Impact) Energy Savings
❖ EnergyStar – 0.4 (840260677 KWh)
❖ CIPrescript_Custom – 0.36 (840092675 KWh)
❖ ResCFL_LED – 0.35 (840092675 KWh)
❖ CICFL_LED - 0.32 (839840673 KWh)
• Investment Benefit
• Avoided Health Impact
26 Eligible Studies (92 Subgroups Coded)
92 Subgroups
❖ EnergyStar (20)
❖ ResCFL_LED (31)
❖ CIPrescript_Custom (23)
❖ CICFL_LED (18)
Comprehensive Meta-Analysis (CMA)
Overall Summary Effect Size (Impact) for the Programs 0.36 in Hedges' g
Findings
❖ 3360286700 KWh
❖ $11 billion
❖ Avoided Pollutants $36 to $81 millions
❖ GHG Emission 2610775 (tons)
Total Energy Savings 3360286700 KWh
• Energy Saved
• GHG Avoided
eGRID2014 Table
Equivalent Calculation
❖ Carbon Dioxide (CO2) Captured Transported in Pipeline for Storage Deep underground rock formation
❖ Carbon Tax Applied for Generation
❖ Carbon Credit Applied for Mitigation
Emissions of GHG & Pollutants (tons)
❖ 2610775 CO2
❖ 5890 SO2
❖ 23520 NOX
Co-Benefits Risk Analysis (COBRA)
SO2
NOX