Transforming Lighting Markets in Argentina, Peru, the Philippines, and South Africa

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ABSTRACT

Market transformation programs create new challenges and opportunities for program evaluators. On the one hand, traditional evaluation techniques such as use of pre/post comparisons with treatment and control groups may not be possible if the treatment group is potentially the whole population. On the other hand, econometric techniques, such as the interrupted time-series model, can potentially deal with confounding market effects including free riders and spillover in a comprehensive and credible manner. This paper applies the interrupted time-series model to four lighting transformation programs, undertaken as part of the Efficient Lighting Initiative.

The Efficient Lighting Initiative (ELI) was a seven-country program implemented by the International Finance Corporation in Argentina, the Czech Republic, Hungary, Latvia, Peru, the Philippines and South Africa. The objective of the overall ELI program was to reduce greenhouse gas emissions by promoting the use of modern and high-quality lighting products to transform domestic lighting markets. Through these market interventions, ELI sought to achieve its goals by: (1) providing consumers with reliable information with which they can make educated purchasing decisions and which will allow high-quality lighting products to compete fairly; (2) strengthening the manufacturing, service, distribution and retail capacity of the local efficient lighting market; and (3) supporting commercial financial mechanisms that will allow more consumers to purchase energy-efficient lighting products. This paper estimates ELI program impact on energy consumption and emissions.

Introduction

Market transformation programs create new challenges and opportunities for program evaluators. On the one hand, traditional evaluation techniques such as use of pre/post comparisons with treatment and control groups may not be possible if the treatment group is potentially the whole population. On the other hand, econometric techniques, such as the interrupted time-series model, can potentially deal with confounding market effects including free riders and spillover in a comprehensive and credible manner. This paper applies the interrupted time-series model to four lighting transformation programs, undertaken as part of the Efficient Lighting Initiative.

Several previous studies have used econometric methods to analyze the impact of market transformation programs. Duke and Kammen [1] found that accounting for interaction between the demand response and production response for electronic ballasts increases the consumer benefit cost ratio. Horowitz [2] found that coordinated national electronic ballast programs were more cost effective than local efforts. Horowitz and Haeri [3] found that the cost of energy efficiency investments was fully capitalized in housing prices and that purchasing an energy efficient house was cost effective. Jaffe and Stavins [4] found that insulation levels in new residential housing appropriately reflect energy prices. Nadel, Thorne, Sachs, Prindle and Elliott [5] provide a comprehensive overview of market transformation activities in the United States. Tiedemann [6] applies an econometric approach similar to that used here to an analysis of the China Green Lights program. This paper uses econometric analysis and simple engineering algorithms to examine the impact of the ELI program on sales of energy efficient lighting and on emissions in four developing-country ELI participants including Argentina, Peru, the Philippines and South Africa.

An outline of the paper is as follows. The next sections provide a brief overall description of the ELI program, with a brief description of the four programs examined in this study. This is followed by an outline of the economic model of market transformation used in the study. The substantive results are covered in the next three sections which look at the impact of ELI on sales of CFLs, sales of efficient fluorescent tubes, electricity consumption and emissions of carbon dioxide, sulphur dioxide and nitrogen oxides. The final section provides the study summary and conclusions.

ELI Program Description

The Efficient Lighting Initiative (ELI) is a seven-country program implemented by the International Finance Corporation in Argentina, the Czech Republic, Hungary, Latvia, Peru, the Philippines and South Africa. The objective of the overall ELI program is to reduce greenhouse gas emissions by promoting the use of modern and high-quality lighting products to transform domestic lighting markets.

The markets for lighting products in the four developing ELI countries reflect the economic and social dualism characteristic of these countries. Lower income residential customers typically purchase their lamps at smaller grocery and general-purpose stores. These stores frequently carry only 25W to 100W GLS lamps. Middle income and upper income residential customers have access to wide variety of stores including department stores, hypermarkets, chain stores, hardware stores and lighting stores. These stores carry a wider range of lighting products including a variety of GLS lamps, a range of CFLs, energy efficient T5 and T8 tubes and T12 tubes.

Business customers, especially those in urban areas, have a wider range of options. These include building supply stores, larger hardware stores and full service lighting stores, which often carry a full range of lighting products. Domestic manufacturing of lighting products is limited in the ELI countries, with most efficient products being imported. Given their small domestic markets, all developing ELI countries have problems achieving economies of scale.

Each program initiative falls into one of five methods of market intervention: public awareness and education, utility programs, transaction support, market aggregation, and financial incentives. Through these market interventions, ELI sought to achieve its goals by:

- Providing consumers with reliable information with which they can make educated purchasing decisions and which will allow high-quality lighting products to compete fairly.
- Strengthening the manufacturing, service, distribution and retail capacity of the local efficient lighting market.
- Supporting commercial financial mechanisms that will allow more consumers to purchase energy-efficient lighting products.

Argentina ELI

The domestic lighting industry in Argentina is based on the production of standard efficiency lighting products. Argentina relies on imports for more efficient lighting products such as CFLs, T8 tubes and electronic ballasts. A pre-program launch survey examined the lamp purchasing patterns of various groups of customers. About 63% of those surveyed buy lamps at the super market, while 11% buy lamps at lighting shops, 10% at hardware stores, 9% at grocery stores and 7 % at other establishments. While for all groups, supermarkets are the lamp-purchasing place of choice, higher socio-economic groups are more likely to use lighting shops than other groups. Lower socio-economic groups are more likely to use grocery stores than are other groups.

ELI Argentina focused its activities on the residential sector, while the Argentina Street Lighting Program, a separate GEF program, was aimed at improving street lighting efficiency. Key aspects of the ELI Argentina program included the following:

- Increasing consumer awareness of the nature of and potential benefits of energy efficient lighting.
- Promoting screw base integral CFLs through multimedia marketing and a schools education program.
- Promoting the sale of CFLs with payment through electric bills or through paycheck deductions.
- Focusing on specialised training programs and other activities for professionals to encourage energy efficient lighting design and retrofits in public and commercial buildings.
- Supporting the establishment of Energy Service Companies (ESCOs).

Peru ELI

Peru gained its most significant experience with energy efficiency in 1994, when the country faced an electricity shortfall. To avoid this problem, the Ministry of Energy and Mines (MEM) created a national Energy Savings Program (PAE) to administer a series of energy efficiency initiatives aimed at reducing peak hour demand by 100 MW. PAE implemented these programs in conjunction with CENERGIA, a local NGO dedicated to energy conservation. The PAE-CENERGIA campaign successfully avoided the crisis, but mainly served middle and high-income citizens in the capital city of Lima. The PAE program has been continued since 1994 in a scaled-down form because of its cost saving benefits. ELI will complement and co-ordinate with this ongoing effort, specifically targeting the previously under-served constituencies of low-income families and those living outside of Lima.

Peru's residential lighting market is still dominated by incandescent sources. Although the PAE-CENERGIA campaign raised CFL sales from 40,000 in 1994 to 415,000 in 1995, sales subsequently dropped when intensive CFL promotion ceased. As for the commercial lighting market, most of the linear fluorescent tubes installed in Peru are the less efficient T-12 type. Although most companies could save money by replacing T-12 fluorescent tubes with the higher efficiency T-8s, many customers are unaware of this opportunity. In addition, some companies have the mistaken impression that T-8 tubes provide less light because they are thinner in diameter. Encouragingly, an increasing number of companies have been willing to switch from T-12 to T-8 linear fluorescent tubes over the past two years.

Philippines ELI

Compared to many low-income, developing countries, the Philippines has relatively modern and sophisticated lighting sector. A detailed market assessment report, conducted before ELI program launch, concluded that CFLs accounted for 64% of all household lighting and 77% of lighting used in large firms. The sophistication on the demand side has not been matched on the supply side, as Philips withdrew the last major CFL manufacturing plant in the country in 1999, and GE discontinued its small magnetic ballast-manufacturing site late in 2000. Neither produced ELI-compliant products (qualified under ELI's global lighting product specifications) at the time they were closed.

The majority of lighting product imports came from low-cost Asian producers, with some 50 CFL importers bringing their products into the country, selling their goods at hardware stores and supermarkets as well as at informal venues such as sidewalk stalls. According to the Department of Trade and Industry, only 18 of those 50 importers were approved for importation in 2000, with only three brands initially identified by the ELI program as meeting ELI standards. With European market theoretically closed to low quality CFLs, the Philippines had become one of the principal targets for low-cost and sometimes low quality CFLs.

South Africa ELI

South Africa relies substantially on high quality lighting products imported by the major multi-national lighting companies and on lower quality/lower cost imports from Asia. There was formerly limited local manufacturing of CFLs, but this facility has now closed due to low output and consequent high costs. Some ten years ago, Osram opened a factory to manufacture fluorescent tubes and high intensity discharge lamps, but this facility was closed due to strikes. There is still some limited domestic production of tubes and lamps, as well as more extensive production of ballasts and luminaires.

Initial attempts to develop the South Africa market for high efficiency lighting products began in November 1996, when Eskom and a local grocery chain launched a pilot CFL program. This initial effort met with some success, but encountered difficulties as some imported CFLs had very high failure rates. Following further discussions, Eskom signed a contract with IFC in May 1998 to develop a business plan for a South Africa ELI program and launched a series of research investigations aimed at optimizing the design of an efficient lighting program that would meet the special needs of South Africa.

In January 2000, South Africa ELI was launched with Technology Services International (TSI) managing the initial advertising, promotional and development activities. The formal launch of the proposed two-year program was in July 2000 and involved a variety of high profile promotional activities. Bulk subsidized sales of CFLs began in October 2000, with a re-launch of the program in December 2000 and emphasis on CFL sales activities for the remainder of that year. The revised plan for 2002 emphasized the commercial, institutional and industrial sectors. Following two extensions of six months and three months respectively, major ELI program activities were completed by the end of March 2003. The on-going activities of Bonesa were subsequently folded into Eskom. South Africa ELI included nine main programs. These strategies include public education, utility programs, market aggregation, financial incentives and transactions support. The relevant market sector addressed by each of the South Africa ELI programs is also indicated.

Model and Estimation

It is convenient to view a single lamp or tube market (such as the market for compact fluorescent lamps or energy efficient fluorescent tubes) in isolation and abstract from linkages to other markets or general equilibrium effects. Consider the following simple four-equation model where (1) is the demand curve for a specific lighting product, (2) is the stochastic process for the path of income over time, (3) is the supply curve for the lighting product, and (4) is the stochastic process for import prices over time, and the error terms have been suppressed for convenience.

(1) $\text{quantity}_t = a + b^* \text{price}_t + c^* \text{income}_t + d^* \text{dummy}_t$
(2) $\text{income}_t = e + f^*\text{time}_t$
(3) $\text{price}_t = g + h^* \text{world price}_t + i^*\text{dummy}_t$
(4) $\text{import price}_t = j + k^*\text{time}_t$

In these equations, quantity_t is domestic market demand for the lighting product at time t, price_t is unit price of the lighting product at time t, income_t is total domestic income at time t, time_t is the year t, world price_t is the per unit at time t, and dummy_t is a shift variable that takes the value

"0" in the pre-China Green Lights program period and the value "1" in the China Green Lights program period.

Substituting for income in (1) and substituting for price in (3) yields a simple structural equation model with two equations in two variables, quantity and price. Solving this model for price and for quantity, yields in turn the reduced form of this structural model as follows:

(5) $quantity_t = \alpha + \beta*time + \chi*dummy_t$

(6) $price_t = \delta + \phi*time + \gamma*dummy_t$

Equation (5) represents the reduced form equation for quantity. Note that it has been rearranged so that quantity depends on a constant plus a time trend plus a term that represents program impacts. Equation (6) represents the reduced form equation for price, which in this model is the same as the supply equation. Note that it has been rearranged so that price depends on a constant plus a time trend plus a term that represents program impacts.

Impact on CFL Sales

Table 1 shows estimated sales of CFLs in Argentina, Peru, the Philippines and South Africa. In all four countries, sales of CFLs have grown substantially over the period covered, and these sales have also grown more rapidly than the lighting market as a whole. Sales of CFLs in Argentina in 2001 and in South Africa in 1999 were negatively affected by the economic crises in those countries for those years.

Table 1. Estimated CFL Sales (Thousands)

	Argentina	Peru	Philippines	South Africa
1997	1,400	110	4,400	1,448
1998	1,700	150	4,300	1,656
1999	2,900	260	3,900	1,908
2000	5,827	742	4,500	2,520
2001	7,598	1,286	4,692	4,007
2002	1,962	2,805	4,899	5,026
2003	7,661	-	-	5,304

Table 2 explains the impact of ELI on sales of CFLs, where we use an OLS econometric model in which sales in thousands of units are a function of a time trend and a dummy variable for the ELI program. For Argentina and South Africa, the models also include an additional dummy variable to adjust for the effects of the 2001 and 1999 economic crises respectively. All four models have adequate fits to the data, with adjusted R-squared values ranging from 0.35 to 0.97.

The one-year estimated increase in sales due to ELI is 1,021,000 units in Argentina, 1,412,000 units in Peru, 491,000 units in the Philippines and 1,246,000 units in South Africa. The two-year ELI program impact for each product in each country then equals twice the one-year ELI impact. The period covered by the analysis includes the years 1998 through 2003 for Argentina and South Africa and the years 1998 through 2002 for Peru and the Philippines.

Table 2. Impact of ELI on CFL Sales, OLS Regressions (Thousands)

	Argentina	Peru	Philippines	South Africa
Constant	348 (0.26)	-374 (-1.64)	4,251 (13.08)	820 (2.85)
Year	1,043 (2.22)	294 (4.29)	10 (0.08)	452 (4.35)
ELI	1,021 (0.52)	1,412 (4.49)	491 (1.15)	1,246 (2.84)
Devaluation	-5,668 (-3.73)	-	-	-268 (-0.84)
Adjusted R^2	0.80	0.96	0.35	0.97
DW	1.35	1.64	2.90	2.19

Note: T-statistics for coefficients are shown in parentheses. DW is the Durbin-Watson statistic.

For each regression, the coefficients for each variable are given in the appropriate column with the t-statistic below in parentheses. The R-squared statistic adjusted for degrees of freedom (a measure of goodness of fit) and the Durbin-Watson statistic (a measure of auto-correlation) are also shown. Auto-correlation refers to the possibility that the error terms in the regression are correlated over time. When auto-correlation is significant, application of ordinary least squares regression may lead to inefficient estimates of regression coefficients. The possible presence of auto-correlation is tested using the Durbin-Watson statistic. In general, values of this statistic close to 2.0 are preferred, while values further from 2.0 are less preferred.

Table 3 explains the impact of ELI on sales of CFLs, where we use a ML econometric model in which sales in thousands of units are a function of a time trend and a dummy variable for the ELI program. As before, the Argentina and South Africa models also include an additional dummy variable to adjust for the effects of the 2001 and 1999 economic crises. In general, the ML models in Table 2 are superior to the OLS models in Table 1. The value of adjusted R-squared is often used as a selection criteria in comparing alternative models, the idea being that a model with superior explanatory power is preferred, other things being equal.

The adjusted R-squared values are higher for the ML models than for the OLS models. In the case of Argentina and the Philippines the difference in explanatory power is substantial, whereas in the case of Peru and South Africa the difference in explanatory power is negligible. Overall, the ML regressions are preferred. The one-year estimated increase in sales due to ELI is 963,000 units in Argentina, 1,367,000 units in Peru, 759,000 units in the Philippines and 1,325,000 units in South Africa.

It is worth noting that using a ML model improves the Durbin-Watson statistic in the case of Argentina and South Africa, but it worsens the Durbin-Watson statistic in the case of Peru and the Philippines. In other words, using a ML model improves the auto-correlation in the case of Argentina and South Africa, but it worsens auto-correlation in the case of Peru and the Philippines.

Table 3. Impact of ELI on CFL Sales, ML Regressions (Thousands)

	Argentina	Peru	Philippines	South Africa
Constant	485 (0.35)	-355 (-1.44)	4,363 (22.04)	837 (3.15)
Year	998 (2.27)	294 (4.00)	-51 (-0.69)	437 (4.11)
ELI	963 (0.55)	1,367 (4.48)	759 (2.84)	1,325 (2.83)
Devaluation	-5,587 (-4.65)	-	-	-271 (-0.76)
Adjusted R^2	0.90	0.97	0.63	0.99
DW	1.51	1.38	3.18	2.16

Note: T-statistics for coefficients are shown in parentheses. DW is the Durbin-Watson statistic

Impact on Efficient Fluorescent Tube Sales

Table 4 shows estimated sales of efficient T5 and T8 fluorescent tubes in Argentina, Peru, the Philippines and South Africa. In all four countries, sales of CFLs have grown significantly.

Table 4. Estimated T5/T8 Sales (Thousands)

	Argentina	Peru	Philippines	South Africa
1997	7,320	241	2,450	5,294
1998	7,320	244	2,550	5,772
1999	7,654	373	2,550	4,500
2000	7,175	393	2,600	5,446
2001	7,488	523	2,750	5,920
2002	7,614	951	2,900	5,704
2003	8,473	-	-	5,309

Table 5 explains the impact of ELI on sales of efficient fluorescent tubes, where we use an OLS econometric model in which sales in thousands of units are a function of a time trend and a dummy variable for the ELI program. For Argentina and South Africa, the models also include an additional dummy variable to adjust for the effects of the 2001 and 1999 economic crises respectively. The model fit for Argentina is poor but is good for the other three countries.

The one-year estimated increase in efficient fluorescent tube sales due to ELI is 146,000 units in Argentina, 382,000 units in Peru, 124,000 units in the Philippines and 425,000 units in South Africa. The two-year ELI program impact for each product in each country then equals twice the one-year ELI impact.

Table 6 explains the impact of ELI on sales of efficient fluorescent tubes, where we use a ML econometric model in which sales in thousands of units are a function of a time trend and a dummy variable for the ELI program. The Argentina and South Africa models also include an additional dummy variable to adjust for the effects of the 2001 and 1999 economic crises. In general, the ML models in Table 2 are superior to the OLS models in Table 1. The value of adjusted R-squared is often used as a selection criteria in comparing alternative models, the idea being that a model with superior explanatory power is preferred, other things being equal.

Table 5. Impact of ELI on T5-T8 Sales, OLS Regressions (Thousands)

	Argentina	Peru	Philippines	South Africa
Constant	7,034 (16.38)	141 (3.48)	2,401 (43.0)	5,685 (17.63)
Year	134 (0.88)	71 (5.84)	55 (2.70)	-78 (-0.67)
ELI	146 (0.23)	382 (6.83)	124 (1.69)	425 (0.86)
Devaluation	-367 (-0.74)	-	-	-952 (-2.68)
Adjusted R^2	0.13	0.98	0.92	0.59
DW	1.43	3.30	2.22	1.87

Note: T-statistics for coefficients are shown in parentheses. DW is the Durbin-Watson statistic.

Table 6. Impact of ELI on T5-T8 Sales, ML Regressions (Thousands)

	Argentina	Peru	Philippines	South Africa
Constant	7,026 (15.77)	132 (29.91)	2,453 (84.2)	5,770 (25.42)
Year	140 (0.95)	72 (52.40)	34 (3.14)	-122 (-1.13)
ELI	151 (1.22)	417 (43.01)	177 (4.58)	650 (1.30)
Devaluation	-389 (-0.91)	-	-	-704 (-1.75)
Adjusted R^2	0.54	0.98	0.89	0.59
DW	1.80	2.79	2.84	1.95

Note: T-statistics for coefficients are shown in parentheses. DW is the Durbin-Watson statistic.

The adjusted R-squared values are similar for three of the ML models than for the OLS models. In the case of Argentina, the difference in explanatory power is substantial, whereas in the case of Peru, the Philippines and South Africa the difference in explanatory power is negligible. Overall, the ML regressions are slightly preferred. The one-year estimated increase in sales due to ELI is 151,000 units in Argentina, 417,000 units in Peru, 177,000 units in the Philippines and 650,000 units in South Africa.

It is worth noting that using a ML model improves the Durbin-Watson statistic in the case of Argentina, Peru and the Philippines, but it worsens the Durbin-Watson statistic in the case of South Africa. In other words, using a ML model improves the auto-correlation in the case of Argentina, Peru and the Philippines, but it worsens auto-correlation in the case of South Africa.

Impact on Energy Use and Emissions

Energy savings were estimated for CFLs and T5/T8 tubes. Energy savings are defined as change in load multiplied by average annual hours multiplied by ELI program impact on sales. For GLS lamps, it is assumed that an 18 watt CFL replaces, on average, a 75 watt GLS lamp leading to a change in load of 57 watts. Average hours of use are assumed to be 2.5 hours per day or 912 hours per year. For fluorescent tubes, it is assumed that a 32 watt T8 tube replaces a 40 watt T12 tube leading to a change in load of 8 watts. Average hours of use are assumed to be 4 hours per day for CFLs and 5 hours per day for T8s.

The unit savings results are shown below. Estimated savings per unit are 83.2 kWh per year for a CFL replacing a GLS lamp and 14.6n kWh per year for a T8 lamp replacing a T12 lamp. These results are the estimated savings that would be experienced at the customers' meters. At the system level, savings would be about ten percent higher to allow for transmission losses and distribution losses.

Table 7. Customer Savings at the Meter

	Base lamp (W)	Efficient lamp (W)	Unit savings (W)	Hours (per year)	Unit meter savings (kWh)	Lime Loss Factor	Unit busbar savings (kWh)
CFL vs. GLS	75	18	57	1,460	83.2	1.10	91.5
T8 vs. T12	40	32	8	1,825	14.6	1.10	16.1

Energy savings were calculated for each product in each country as the product of units savings multiplied by ELI sales impacts for the relevant product type. Savings for each country were then calculated as the sum of savings for each product in that country.

Table 8. Total Energy Savings

	CFL			T5-T8			Total
	Unit bus savings (kWh)	Units (millions)	Sub-total savings (GWh)	Unit bus savings (kWh)	Units (millions)	Sub-total savings (GWh)	Total savings (GWh)
Argentina	91.5	1.926	176.2	16.1	0.302	4.9	181.1
Peru	91.5	2.734	250.2	16.1	0.834	13.4	263.6
Philippines	91.5	1.518	138.9	16.1	0.354	5.7	144.6
S. Africa	91.5	2.650	242.5	16.1	1.300	20.9	263.4

In preparing greenhouse gas inventories, there is typically emphasis on algorithms that estimate emissions as the product of emission factors multiplied by fuel consumption multiplied by the appropriate oxidization fraction. The Intergovernmental Panel on Climate Change has suggested three main approaches to the analysis of greenhouse gas emissions as follows. Tier 1 emission factors represent average emissions per unit of fuel consumed and are not technology specific. Like the other IPCC emission factors, the Tier 1 factors are expressed in terms of quantity of emissions per terajoule of energy, so that fuel data in mass or volumetric terms must be converted to their energy equivalents before the emission factors can be applied. Tier 2 emission factors provide a more detailed approach by disaggregating fuel consumption data using types of technologies that are homogenous enough to realistically permit the use of representative emission factors. Tier 3 emission factors are site and plant specific emission factors and require considerable detailed information. This study uses essentially a Tier 1 analysis, with estimated country-specific emissions factors as shown in Table 9.

Table 9. Annual Energy Savings and Emissions Reductions

	Energy savings (GWh)	CO_2 per kWh (kgms)	SO_2 per kWh (gms)	NO_x per kWh (gms)	CO_2 total (ktonnes)	SO_2 total (tonnes)	NO_x total (tonnes)
Argentina	357.3	0.27	2.46	1.12	100.7	917.8	417.9
Peru	513.8	0.36	3.28	1.49	185.0	1,685.3	765.6
Philippines	283.5	0.39	3.56	1.61	110.6	1,009.3	456.4
S Africa	505.9	1.17	10.67	4.84	591.9	5,398.0	2,448.6
Total	1,660.5				988.2	9,010.4	4,088.5

Conclusions

The purpose of this paper is to develop and apply an interrupted time-series model to market transformation programs in Argentina, Peru, the Philippines and South Africa. As noted above, market transformation programs create new challenges and opportunities for program evaluators. On the one hand, traditional evaluation techniques such as use of pre/post comparisons with treatment and control groups may not be possible if the treatment group is potentially the whole population. On the other hand, econometric techniques, such as the interrupted time-series model, can potentially deal with confounding market effects including free riders and spillover in a comprehensive and credible manner.

The four developing countries ELI programs had a number of major impacts, including the following. First, sales of compact fluorescent lamps increased by 1,926,000 units in Argentina, 2,734,000 units in Peru, 1,518,000 units in the Philippines and 2,650,000 units per year in South Africa. Second, sales of T5-T8 lamps increased by 302,000 units in Argentina, 834,000 units in Peru, 354,000 units in the Philippines and 1,300,594,000 units in South Africa. Third, total energy savings were some 1,661GWh per year. Fourth, carbon dioxide emissions savings were reduced by about 988 kilotonnes per year; sulphur dioxide emissions savings were about 9,010 tonnes per year; and nitrous oxides emissions savings were about 4,089 tonnes per year.

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