Thailand's Evaluation of Market Transformation Program

Napaporn Phumaraphand, Electricity Generating Authority of Thailand
Natchamai Maharattanawong, Electricity Generating Authority of Thailand

ABSTRACT

Thailand started implementing its first national DSM initiatives in late 1993. The target of electricity savings was set at 238 peak MW and 1,427 GWh/year. Impact evaluations of four market transformation programs were conducted through a series of studies using engineering analysis methods and calibration of significant parameters. The first stage began in early 1997 with monthly reports providing preliminary estimates of program impacts based on engineering assumptions and program data tracking. The second stage was performed two years later in order to further calibrate monthly engineering estimates by retaining a consulting firm to conduct comprehensive evaluations with survey research and end-use metering studies.

In the mean time, another experienced consulting firm was also retained to perform the function of an Independent Monitoring and Evaluation Agency or IMEA (as required by an international aide agency: the Global Environmental Facility (GEF)). The IMEA reviewed and assessed evaluation methodologies and results for their reasonableness and provided recommendations for improvements. These two consulting assignments resulted in a significant adjustment of program impacts for the years up to 1998. The last stage of evaluation activities was conducted by staff in mid-2000.They analyzed data gathered from both consulting efforts and incorporated the latest program tracking data into program evaluation results up to June 30, 2000.

The primary purpose of this paper is to summarize how impact evaluation studies were conducted to validate the demand reductions and energy savings of four Thai DSM programs during the period 1993-2000. The paper addresses key issues studied in each step of the impact evaluation research which resulted in more accurate program results.

Introduction

In 1992, Thailand initiated a US$ 189 million demand-side management (DSM) project to help curb electricity demand growth and promote more energy-efficiency equipment and cost-effective energy services within the country. The project was primarily funded through automatic tariff mechanism for DSM and other variable electricity costs. In addition, the project received a US$ 9.5 million grant from the Global Environmental Facility (GEF), US$ 6.0 million grant from the Government of Australia, and a US$ 25 million concession loan from the Japan Bank for International Cooperation (JBIC).

The Electricity Generating Authority of Thailand (EGAT), as an executing agency, established a DSM office to develop, implement and evaluate national DSM programs and measures, with an overall target of reducing peak demand by 238 MW and annual cumulative energy savings of 1,427 GWh by the end of 1998 [1]

In September 1993, EGAT officially launched the Thai DSM initiative with the following main objectives:

- To stimulate local manufacturers and importers to produce or import energy efficient appliances;

[1] Due to initial implementation delays, the project was extended to June 30, 2000 without target revisions.

- To support and pursue energy efficiency and load management programs to maximize benefits for consumers and the country;
- To offer education, provide incentives, and increase awareness of energy conservation among electricity consumers and affect a change in public attitude; and
- To build sufficient institutional capacity in the electricity sector and the energy-related private sector to deliver cost-effective energy services throughout the economy.

To date, EGAT's DSM Office has developed a strong portfolio of DSM measures, including 19 DSM programs targeting a wide range of sub-sectors, end-uses, and substantially surpassed its original target with 566 MW peak demand reduction and 3,140 GWh energy savings.

This paper examines the impact evaluation of four DSM market transformation programs commenced during 1993-1996. They were Thin Tube (High Efficiency Fluorescent Tube), Compact Fluorescent Lamp programs, High Efficiency Refrigerator, and High Efficiency Air Conditioner. This paper discusses the methodology, key parameters, and how findings from evaluation research affected the saving impacts from these market transformation programs.

Background

Systematic evaluations of EGAT's DSM programs started in 1997. EGAT relied on engineering estimates to determine demand/energy savings attributable to each DSM program. The original evaluation plan called for increasing the precision of these estimates with supplemental data and information. As such, in 1999, EGAT hired consultants to conduct additional evaluation assignments for the initial DSM programs through 1998. The GEF also requested the use of an Independent Monitoring and Evaluation Agency (IMEA) to assess the validity of evaluation results and provide recommendations for improvements. Based on experience from the consultants' works, the evaluation staff of the DSM Office conducted their own evaluation works from 1999 through 2000. The results were subsequently reviewed and accepted by the IMEA.

Initial DSM programs employed a market transformation strategy and were widely recognized for their success in program design. The four market transformation programs addressed in this paper are described below.

High Efficiency Fluorescent Tube (Thin Tube) Program Given the low numbers of domestic manufacturers (five in 1993), EGAT engaged in direct negotiation with manufacturers to switch production from T-12 FTLs (40 W/20 W) to T-8 FTLs (36 W/18 W) or "thin tubes". The production technology was readily available and the incremental cost for T-8 FTLs was minimal, therefore, no additional financial incentives were offered. The only market barrier was customer information. As such, EGAT financed an advertising campaign to promote new energy-saving lamps. Within two years, all manufacturers had completely switched production to thin tubes, and EGAT's advertising campaign substantially accelerated public acceptance of this transition.

Compact Fluorescent Lamp (CFL) Program The program objective was to increase the saturation of CFLs through the bulk purchase of CFLs and to distribute at cost (which was about 40% below prevailing market price). The distribution channels were franchised retail outlets (Seven-Eleven convenience stores).

High Efficiency Refrigerator (Refrigerator) Program This program involved a voluntary agreement by a number of domestic manufacturers to affix energy labels to their locally produced models after testing based on an agreed upon standard and testing procedure. EGAT financed testing costs and media campaigns to educate the public about program information. The label represents a refrigerator model's energy-efficiency rating, estimated annual consumption, and estimated annual cost of operation. The rating or level provides a relative ranking for energy use based on energy efficiency compared to other models tested at the beginning of the program.

High Efficiency Air Conditioner (A/C) Program This was similar to refrigerator labeling, but dealt with more manufacturers (around 55) to affix energy labels to 7,000-24,000 Btu/hr model-A/Cs. Interest-free loans were made available to customers, and financial incentives were provided to A/Cs retailers, as product price differentials were significant. The label represents a model's energy efficiency rating, estimated annual consumption, estimated annual cost of operation, and cooling capacity. The rating, or level provides the relative ranking for energy use based on energy efficiency compared to other models tested at the beginning of the program.

Impact Evaluation Methods and Process of Verification

Engineering analysis was the only method used to estimate demand reductions and energy savings for all four DSM market transformation programs. Most of the engineering algorithms shared a number of consistent features.

kWh savings = Number of units * saving per unit * hours of use per year * free ridership
kW savings = Number of units * saving per unit * coincident peak factor * free ridership

All of them included an adjustment for line losses and reserve margin. Algorithms, parameters, and assumptions were first developed in-house in 1997. The calibration of engineering estimates was made through comprehensive evaluation studies by the evaluation contractor in 1999. The following data collection efforts were conducted:

- Surveys of residential customers (n = 2,111), including program participants and non-participants.
- Surveys of non-residential customers (n = 230), including program participants and non-participants.
- In-person interviews (n = 50) with manufacturers and importers of thin tubes, CFLs, air conditioners, and refrigerators.
- In-person interviews with utility staff.
- Metering of the hours-of-use of residential thin tubes and CFLs, and the hours of compressor operation for air-conditioners and refrigerators.

These studies provided substantial adjustments to the value of the algorithm parameters and, hence impact estimation by program. In the mean time, the IMEA was hired to independently verify the validity of EGAT's evaluation results. The IMEA performed an assessment on topics of importance to EGAT's program evaluation activities. Using engineering analysis, IMEA reviewed impact algorithms, and the source of input data (assumptions) as being collected to improve calculations, and recommended improvements to the algorithms. The IMEA also conducted sensitivity analyses, identifying the algorithm input parameters that had the greatest influence on the accuracy of the final energy savings (kWh) and demand reduction (kW) estimates. A key finding of these analyses was that for each of these four technologies the engineering algorithms were most sensitive to the assumed efficiency levels of the **base** and **efficient** technologies.

Based on its detailed review, the IMEA systematically gathered on-site (field) measurements of actual connected load wattages for each of the four technologies and for base case (non-participant) and efficient case (participant). This was based upon their knowledge of related studies in the U.S., where important adjustments to impact estimates had resulted from direct measurement (spot metering) of connected loads to refine assumptions based solely upon manufacturer's nameplate specification.

Program impact estimation and refinement and verification studies (as mentioned above) resulted in the four program kWh and kW savings up to 1998.

Because of the need to report the achievement of project objectives and output by expiration date of the grant funding, June 30, 2000, EGAT re-calculated the results by making some adjustments to the algorithms using data and information from previous studies, updated program data, and comments from agencies (e.g. the World Bank evaluation mission group representing GEF, and the EGAT resident advisor). The final conclusion was summarized in EGAT's Demand-Side Management Program Evaluation submitted to the World Bank as a part of the GEF Project Implementation Completion Report (December 2000).

Program-specific Studies and Results

Thin Tube Program

Algorithm

kW savings = No.of FTL Sold * (($Watt_{base}$ – $Watt_{ee}$)/1,000) * coincident peak factor * (1-Free rider rate) * (1 + Line Loss Factor) * (1 + Reserve Margin)

kWh savings = No.of FTL Sold * (($Watt_{base}$ – $Watt_{ee}$)/1,000) * Hours of use * (1- Free rider rate) * (1 + Line Loss Factor)

Critical Assumptions Used and The Adjustments (Thin Tube Program)

Variables	Assumptions/Adjustment
No. of FTL sold and segmentation	EGAT assumptions. Forty million lamps were sold in 1992 and projected annually to increase at a rate of 8%/year. Lamp sale by sector was estimated in proportion to lighting energy use in that sector. The assumptions were refined from manufacturer survey information by evaluation contractor and the IMEA verified validity. Critical points regarding sale and market share are discussed in the following sections.
Baseline energy use ($Watt_{base}$) and retrofit fixture energy use ($Watt_{ee}$)	EGAT used nameplate specifications i.e., 40/20 Watt for 4-foot and 2-foot tubes for baseline energy use, and 36/18 Watt for retrofit fixtures. The evaluation contractor did not measure electricity consumption. The IMEA critically commented at this point, and recommended adjustments due to its additional spot metering study. See details in next section.

Variables	Assumptions/Adjustment
Hours of Use	EGAT assumed 1,825 hours/year (5 hrs/day) for residential use and 3,650 hours/year (10 hrs/day) for non-residential use. The evaluation contractor refined these values from its light logger data (3,905 hours/year for non-residential and 1,278 hours/year for residential use. The IMEA accepted these values.
Coincident Peak Factor (CF)	EGAT assumed 100% CF for non-residential and 0% for residential use. The evaluation contractor used light logger data to adjust these values i.e. 72% CF for non-residential and 13.7% for residential use. The IMEA recommendation to separate demand diversity factor and system coincidence was not implemented.
Free rider rate	EGAT assumed 40% based on market share of a manufacturer who switched production to thin tube before program. However, the evaluation contractor did not cover this issue in the survey and stated "since the program did not involve monetary incentives, and there was basically no price difference between the efficient (thin tubes) and standard technology (thick tubes), the free rider ship concept was not applicable."

Details of Some adjustments (Thin Tube Program)

- **Number of FTL Sold** was adjusted using information from a survey of FTL manufacturers. The survey was able to estimate sale of thin tubes in domestic market and sales attributable to Thin Tube program. One manufacturer, representing 40% of FTL market, switched to thin tube program before program initiation in 1993; therefore, this sale was not attributed to the program. During the program implementation period, one manufacturer, representing 30% of the market, changed to thin tube production by November 1994, about a year before the schedule. By October 1995, all manufacturers and importers switched to thin tube production and imports as scheduled in 1995.

Another significant finding was recognized and taken into account during the extension of the evaluation period to June 2000: it was revealed by large multi-national manufacturers that they would have switched to thin tube production by the end of 1998 even without the agreement with EGAT. Because their market share was about 30% of the total sale, EGAT excluded it from program impacts since 1998 estimation. This finding indicated that the agreement accelerated the transformation of the market about three years earlier than in the absence of the program.

- **Saving per unit or $\text{Watt}_{base} - \text{Watt}_{ee}$**

As EGAT's original impact evaluation methods calculated the change in connected load wattage from the manufacturer's specifications, this, from IMEA's view, did not encompass the actual connected power demand of the target technology. Moreover, from IMEA's sensitivity analyses, a key finding was that for each of these four technologies, the engineering algorithms are most sensitive to the assumed efficiency levels of the replaced and new tubes. A five percent increase in the base consumption (from 40 to 42 Watts) creates a 50% increase in the saving found by the algorithm. Similarly, a 5% increase in the wattage of the new, efficient technology (from 36 to 37.8 Watts) creates a 45% decrease in savings. Therefore, IMEA's independent data collection embarked on spot watt measurements (spot metering) to refine the base and efficient case assumptions for the connected load of the thin tube to improve the engineering estimates of energy impacts.

An engineering protocol for a series of bench tests of FTL/ballast combinations was designed, and then the tests were conducted. The summary of bench testing results is shown in Table 1.

Table 1: Summary Results from Bench Testing for Thin Tubes

Ballast type	Baseline Watts/Lamp	Energy Efficient Watts/Lamp	Difference	Standard Deviation	N
		4-Foot Lamps			
Electronic	38.1	32.6	5.5	1.1	4
Low Watt Loss	43.9	37.3	6.6	1.2	4
Magnetic	48.0	41.8	6.2	1.1	4
		2-Foot Lamps			
Electronic	18.3	17.3	1.0	0.7	2
Low Watt Loss	23.8	20.5	3.3	0.4	2
Magnetic	27.1	24.8	2.4	0.2	2

In summary, the savings due to changing out a T-12 lamp to a T-8 lamp appeared to be on the order of 5.5-6.6 watts for 4-foot fixtures and greater than 2 watts for 2-foot fixtures. IMEA also cited information from the evaluation contractor's survey that the majority of customers did not replace their FTL ballasts when they replaced thick tubes with thin tubes-i.e., both the base case and the energy efficient case assumed magnetic ballasts. Then IMEA recommended that for 4-foot lamps the per unit savings of 6.4 Watts be used and for 2-foot lamps, the per unit savings of 2.4 Watts be used. These changes implied significant increases in the peak MW and energy reductions of the program.

Compact Fluorescent Lamp (CFL) Program

Algorithm

kW saving_i = (No. of CFL Sold)$_i$ * $((\text{Watt}_{base} - \text{Watt}_{ee}) / 1000)$ * coincident peak factor * $(1 - FR_i)$ * (1+ line loss factor)* (1 + reserve margin)

kWh saving_i = (No. of CFL Sold)i * $((\text{Watt}_{base} - \text{Watt}_{ee}) / 1000)$ *hours of use$_i$ * $(1 - FR_i)$ * (1+ line loss factor)

Critical Assumptions Used and The Adjustments (CFL Program)

<u>Variables</u>	<u>Assumptions/Adjustments</u>
No. of CFL Sold	Program used annual sales data (adjusted for 10% inventory). This assumption was used through the final stage of evaluation. On average, 88% of total participant lamps was sold to residential and 12% to nonresidential customers.

Variables	Assumptions/Adjustments
Saving per unit ($Watt_{base}$ - $Watt_{ee}$)	The wattage of the baseline fixture was based on standard incandescent nameplate specification (in the range of 25 Watt – 100 Watt). The wattage of the energy-efficient fixture was based on the CFL nameplate specification (in the range of 9 Watt – 20 Watt). The evaluation contractor refined the value using survey and secondary data. The IMEA did some analysis but did not recommend any adjustments due to insufficient details of the evaluation contractor's sampling methodology. (See details below)
Coincident Peak Factor (CF)	Based on a power system peak during 2-5 p.m., EGAT assumed a zero CF (0%) for residential use and 100% CF for non-residential use. These values were adjusted using data from the evaluation contractor's light loggers to measure duration and time of use. The metered data resulted in residential CF of 25% and nonresidential CF of 49%.
Hours of use	EGAT assumed 1,825 hours/year (5 hrs/day) of residential use and 3,650 hours/year (10 hrs/day) of non-residential use. The evaluation contractor refined this assumption using light loggers data. The results were slightly different with 1,779 hrs/year (4.9 hrs/day) for residential and 4,015 hrs/year (11.0 hrs/day) for nonresidential use.
Free rider rate	No assumptions were specified (0% applied). Non-residential surveys estimated a 72% of free rider rate. This rate was applied to the EGAT 2000 evaluation only.

Details of Some Adjustments (CFL Program)

CFL-Saving per Unit ($Watt_{base}$ – $Watt_{ee}$) For the baseline wattage of incandescent lamps replaced by CFL, the evaluation contractor derived the value from residential survey responses. For the non-residential sector, base watts were the average wattage of incandescent lamps from the New Building Design Study (NEOS Corporation, September 1998). The IMEA conducted spot watt measurements and concluded that the measured watts were quite close to the nominal watts (at worst 97% of nominal value and average 98% for residential and average 99% for non-residential). Therefore, the methodology and values for the base wattage assumptions appeared to be valid.

For energy-efficient watts, the evaluation contractor assumed the values to be equal to the nominal watts. The IMEA spot watt measurements indicated that residential CFL_s typically consumed less electricity; on average, they were measured at 75% of their nominal rating. This would imply that the calculated savings for residential sector *underestimate* the true savings. The nonresidential CFL_s consumed slightly more than their nominal rating at 109%, indicating that the calculated savings *overestimate* the true savings. However, the evaluation contractor did not provide sampling procedure information such as how the respondents were selected, the opportunistic nature of where logger metering was done, and how particular fixtures at a home or business were selected. In the absence of sampling detail that could yield case weights, the IMEA had no basis to recommend any adjustments to the energy-efficient watts.

High Efficiency Refrigerator Program

Algorithm

kW $saving_i$	=	(No. of Refrigerator Sold) * $(1\text{-inventory})_i$ * (Base – New_i) / 8,760 * Coincident Peak Factor * (1 + line loss factor) * (1 + reserve margin)
kWh $saving_i$	=	(No. of Refrigerator Sold) * $(1\text{-inventory})_i$ * (Base – New_i)* (1 + line loss factor)

Critical Assumptions Used and The Adjustments (Refrigerator Program)

Variables	Assumptions/Adjustments
i	Refrigerator model. Majority of refrigerators for residential use in Thailand was one-door unit models.
No. of Refrigerator Sold	Sale of models i refrigerator based on label requested from manufacturers and supplied by EGAT.
Inventory Ratio	EGAT assumption (10%) No. of units sold and inventory ratio were refined through data from manufacturer surveys by the evaluation contractor.
Base	Baseline energy consumption in kWh/year. EGAT used pre-program (Nov. 1994) average testing result of 485 kWh/year/unit which was determined as mean level (level 3) annual energy use.
New_I	Tested energy consumption of new refrigerator model I, also in kWh/year. The result was used in determining the efficiency level that appeared on label. See details of baseline and saving estimate refinement in next section.
Hours of operation and compressor running time	In original algorithm, 24 hours/day (8,760 hours/year) of operation hours was assumed. The evaluation contractor metered the compressor running time and found that it was only 25% of the previous assumption. No further adjustment was recommended by IMEA.
Coincident Peak Factor (CF)	Originally, EGAT assumed 100% CF. The evaluation contractor used metering data to adjust the value. It was only one-fifth of EGAT's previous value.

Details of Some Adjustments (Refrigerator Program)

Baseline Energy Use and Saving Estimate Based on the IMEA's sensitivity analysis, the algorithm was most sensitive to the value chosen for the base level of energy consumption. A five percent increase in the base consumption (from 485 kWh/year to 509 kWh/year) created a 28.5% increase in the savings estimated by the algorithm. Nevertheless, EGAT's assumption on baseline energy use (485 kWh/year/unit) was used by the evaluation contractor, which the IMEA indicated strongly that the value seemed high or inappropriate, since the average value was not weighted by sales. The average was representative of those offered for sale in Thailand, but not necessarily representative of the population of refrigerators in Thailand. Regarding IMEA's opinion on this issue, a final conclusion was reached with market average efficiency in January 1995, at the start of the program, (i.e. 435 kWh/year/unit) as the baseline. The IMEA noted that it was a reasonable approximation of the conditions at the start of the program. The baseline energy use of 435 kWh/year/unit was used in EGAT's June 2000 evaluation.

With-Load Energy Consumption Factor. Refrigerator testing used "no-load" energy use, and EGAT originally (in 1997) assumed about 56% higher energy use than the no-load case. However, EGAT conducted with-load testing of some refrigerators and found that the with-load unit's energy use was only about 12% higher than no-load unit. Unfortunately, this information came up late and was only considered in EGAT's June 2000 evaluation.

High Efficiency Air Conditioners (A/C) Program

Algorithm

$$\text{kW saving}_I = (\text{No. of A/C}_s\ \text{Sold})_I * (1\text{-Inventory}) * (\text{Btu/hr})_I * (1/\text{EER}_{base} - 1/\text{EER}_{new}) * \text{Load Factor} * (1 - \text{Free rider rate}) * (1 + \text{line loss factor}) * \text{Coincident Peak Factor} * (1 + \text{reserve margin})$$

$$\text{kWh saving}_I = (\text{No. of Acs Sold})_I * (1\text{-Inventory}) * (\text{Btu/hr})_I * (1/\text{EER}_{base} - 1/\text{EER}_{new}) * \text{Load Factor} * (1 - \text{Free rider rate}) * (1 + \text{line loss factor})$$

Critical Assumptions Used and The Adjustments (A/C Program)

Variables	Assumptions/Adjustments
i	A/Cs model. Program participants were split-type room Acs with capacity ranging from 7,500-24,000 Btu/hr.
No. of A/Cs sold	EGAT assumed sale of model i A/Cs based on label requested from manufacturers and supplied by EGAT.
Inventory Ratio	EGAT assumed 5% The evaluation contractor surveyed manufacturers for sales estimates by product type and measured inventories. EGAT split A/C sale to residential and non-residential sector was based on in-house developed telephone survey. The proportion was 80:20 (R : Non-R). EGAT, therefore, separated the A/C impact estimation for residential and non-residential in its June 2000 evaluation.
Baseline electricity use and efficiency (EER_{base})	EGAT assumed a 7.6 EER A/C for base case. The evaluation contractor did not use their loggers to measure consumption, only run-time. They continued to use the baseline estimate of 7.6 EER. The IMEA did spot-watt measurement and indicated the impact of A/C program could be lower than reported by evaluation contractor. Details on this issue are presented in the following section.

Variables	Assumptions/Adjustments
Retrofit electricity use and efficiency (EER_{new})	EGAT assumed a model-specific EER based on testing. The evaluation contractor did not measure electricity consumption. They based the usage on the energy-usage rating for the various levels, and the number of models distributed for each level. No adjustment was recommended by IMEA. EGAT used the model-by-model EER based on testing results in its June 2000 evaluation.
Coincident Peak Factor (CF)	EGAT assumed no CF for residential use and 100% for non-residential use due to the system's afternoon peak period. The evaluation contractor refined the value from logger data. IMEA's recommendation to separate demand diversity and system coincidence was not implemented. EGAT separated residential and non-residential CF based on in-house load research data in the June 2000 evaluation. The residential CF was 8.4% and non-residential CF was 85%
Hours of Use and Compressor running time (Load Factor)	EGAT assumed "standard running time" from ANSI/AHAM 1982 (64%) and assumed 10 hours/day of A/C operation time in the residential sector (3,650 hrs/year). The evaluation contractor used loggers to measure run-time of the compressor and adjusted by seasonal adjustment factor resulted in 985 hours/year of residential A/C operation. EGAT used in-house load research data for non-residential A/C with the same method as evaluation contractor did. The result was 1,788 hours/year of non-residential A/C operation.

Details of Some Adjustments (A/C Program)

Baseline Efficiency (EER_{base}) Based on IMEA sensitivity analysis, the engineering algorithm for savings from A/Cs was most sensitive to changes in the assumed level of efficiency of the base technology and the new A/C units. A 5% increase in the assumed EER of the base technology (from 7.6 to 7.98) produced a decline of 21.6% in the savings. Similarly, an increase of 5% in the efficiency of the New A/C unit (for example from 9.75 to 10.24 EER) produced an increase in savings of 16.8%.

Since the impact results were quite sensitive to the baseline consumption value, this assumption carried significant weight in the results. The IMEA conducted spot-watt measurement of A/C units across the residential and nonresidential sectors. Calculations from the spot metered data indicated that the EER of the average residential non-participant was 8.3 and the average nonresidential non-participant was 8.0. These results indicated that the baseline of 7.6 EER was artificially low which would inflate the saving estimates. As such, EGAT improved the impact estimation in the June 200 evaluation using the baseline efficiency of 8.3 EER and 8.0 EER for A/C sales in the residential and nonresidential sectors, respectively.

Comparison of Program Results

Peak Demand Reduction

In Table 2 below, comparison of peak demand reduction by program by each study up to 1998 results were shown.

Table 2: Peak Demand Reductions (MW)

(1) Program	(2) EGAT Estimate (1997)	(3) Evaluation Contractor (1999)	(4) IMEA (1999)	(5) EGAT Evaluation (2000)
Thin Tube Program	425	199	296	319
CFL Program	6	12	n.a.	9
Refrigerator Program	51	14	n.a.	59
Air Conditioner Program	24	18	n.a.	45
Total	**506**	**243**	**296**	**432**

For Thin Tube Program, the main reasons for a decrease in MW reduction in column (3) were adjusted sales number from manufacturer surveys and the adjusted value of CF energy use from metering data. The higher number of MW reduction in column (4) was due to IMEA's spot-watt metering study which resulted in higher saving per unit. In column (5), the MW reduction slightly increased, due to EGAT's adjustment of the CF from the evaluation contractor's average kW to maximum kW value from metered data. The peak demand reduction from the Thin Tube Program accounted for over 70% of the total MW and confirmed the fact that it was EGAT's most successful market transformation program.

For the CFL Program, the MW reduction doubled in column (3) due largely to the adjusted residential and nonresidential CF value from metering data. In column (5), the impact decreased because EGAT applied a free rider rate of 72% to nonresidential impact. This rate was not used in the previous study.

For the Refrigerator Program, the impact in column (3) significantly dropped. There were two reasons for this drop: first, EGAT (1997) assumed 24 hours of operation of refrigerators, but the metering data resulted in one-fourth of EGAT's assumption. Second, the CF value from metering data was only one-fifth of EGAT (1997) assumption. Nonetheless, in column (5), MW reduction increased more than 4 times of the previous studies' impact, because EGAT's testing results with-load energy consumption of refrigerator was about 75% less than the value used in previous studies. In addition, EGAT adjusted the CF value using maximum kW recorded. These two factors resulted in a large increase in MW reduction even though the baseline energy consumption was adjusted.

For the A/C Program, in column (3), MW reduction decreased around 20% due to adjusted A/C sales from the surveys. However, in the EGAT 2000 evaluation, the disaggregation of baseline EER, A/C sales, and CF values into residential and nonresidential sector provided about 2.5 times higher MW reduction.

Energy Reduction

In Table 3, comparisons of energy reduction by program by each study up to 1998 were shown.

Table 3: Energy Reduction (GWh)

(1) Program	(2) EGAT Estimate (1997)	(3) Evaluation Contractor (1999)	(4) IMEA (1999)	(5) EGAT Evaluation (2000)
Thin Tube Program	1,543	1,032	1,525	1,553
CFL Program	81	71	n.a.	54
Refrigerator Program	369	271	n.a.	606
Air Conditioner Program	371	174	n.a.	169
Total	**2,364**	**1,548**	**1,525**	**2,382**

While sales volume, savings per unit and CF values mostly affected peak demand reduction, energy savings had nothing to do with CF values but with hours of use (or operation) instead. Hours of use (or operation) by program by sector were validated using data from the metering study.

For the Thin Tube Program, the adjustments in number of lamp sold by sector, saving per unit, and hours of use by sector contributed to variations in energy savings in 1999 studies column (3) and the EGAT 2000 evaluation.

For the CFL Program, a decrease in energy savings in 1999 studies was mainly due to adjusted hours of use and adjusted lamp sales by sector. The further decrease in the EGAT 2000 study was due to the application of the free rider rate.

For the Refrigerator Program, in column (3), the adjusted hours of operation was the main factor that affected the change in energy savings. This large increase in the EGAT 2000 evaluation was due to increased savings per unit based on the revised with-load energy consumption factor.

For the A/C Program, a large decrease in energy savings in column (3) was from a decrease in hours of A/C operation time from the metering study data.

Conclusion

Program evaluation is an important component of EGAT's nationwide project. Impact evaluation using a calibrated engineering approach served DSM programs well in the first round of evaluations. However, there were several areas where methodological improvements are needed to better support data leveraging approaches which in turn will enhance the validity and reliability of the data collected:

- Improvement in sample design using probability sampling techniques. The techniques relate statistically the probability of a sampling unit (e.g. a customer) being selected, and support inferences from the sample to a population.
- To coordinate program implementation and evaluation so that measurements (such as connected input wattage) can be obtained for both the pre- and post- installation conditions. Reliable pre- and post- program measurements are crucial to strong research design and enable evaluators to attribute changes to a program.
- Methods such as bench tests, in-field spot-watt measurements, and in-field interval metering to obtain in-field performance data can increase the precision and reduce uncertainty in engineering estimates of energy impacts.

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