

**Residential Appliance Efficiency Incentives  
Program:  
High Efficiency Refrigeration  
1996 First Year Statewide Load Impact Study  
Net-To-Gross Analysis**

*Final Report*

SDG&E Study ID #: 980  
PG&E Study ID #: 373-2

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## CHAPTER 1

### EXECUTIVE SUMMARY

This report presents the results of Hagler Bailly's net-to-gross analysis for the first year load impact study for the 1996 refrigerator rebate programs of San Diego Gas & Electric (SDG&E) and Pacific Gas & Electric (PG&E).

#### 1.1 Summary of Method and Results

The methodology employed in this study was in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs" ("Protocols"), as adopted by California Public Utilities Commission Decision 93-05-063, revised January 1997, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, and 96-12-079.

There were seven principal analysis steps completed as part of this methodology:

1. Calculate the **total savings** from all refrigerators purchased in 1996 in the PG&E and SDG&E service territories. (Throughout the report, when we refer to "California" it should be understood that we are referring to the service territories of SDG&E and PG&E only.)
2. Determine the extent of **naturally occurring conservation** in 1996 in California.
3. Calculate **net savings** in 1996 in California by subtracting naturally occurring conservation (Step 2) from total California savings (Step 1).
4. Collect the **gross savings** from rebated refrigerators from PG&E and SDG&E (which were calculated from program tracking records according to rules in Table C-3B of the Protocols).
5. Calculate the **net-to-gross ratio** by comparing net savings (Step 3) with gross savings (Step 4).
6. Disaggregate total savings to quantify the levels of "**true program savings**," "**free rider savings**" and "**spillover savings**."
7. Estimate **precision** of the net-to-gross calculation.

Chapter 2 contains a detailed description of the methodological processes employed for each of these analysis steps, Chapter 3 presents the specific results from each of these steps, and Chapter 4 contains a discussion of issues raised in this analysis. Table 1-1 summarizes the results.

**Table 1-1: Summary Results**

Analysis Step	Description of Analysis	Result
1	Calculate total yearly savings in California	44,767,630 kWh
2	Determine extent of naturally occurring conservation in California	24,284,386 kWh
3	Calculate net yearly savings by subtracting results of Step 2 from results of Step 1	20,483,244 kWh
4	Calculate gross savings from rebated refrigerators	15,697,025 kWh
5	Calculate net-to-gross ratio by dividing results of Step 3 into results of Step 4	130.49%
6	Disaggregate net savings results from Step 3:	
6a	Determine free ridership rate	23.7%
6b	Apply free ridership rate to disaggregate savings	
	Free Rider Savings	3,720,195 kWh
	True Participant Savings	11,976,830 kWh
	Spillover Savings	8,506,414 kWh
7	Precision Results	(See Chapter 3)

## 1.2 Report Organization

This chapter has provided a brief summary of the methods and results of our net-to-gross analysis for energy efficient refrigerators. Chapter 2 provides an overview of the study objectives and a detailed description of the methodology, and Chapter 3 contains the detailed study results. Chapter 4 presents a discussion of issues related to the study methodology and results. There are four appendices attached to this report:

- ▶ Appendix A: M&E Protocols Table 6 for SDG&E<sup>1</sup>
- ▶ Appendix B: M&E Protocols Table 7
- ▶ Appendix C: SDG&E and PG&E Participant Free Rider Survey Instrument
- ▶ Appendix D: Refrigerator Model Number Matches

The reader is encouraged to refer to Hagler Bailly's *Residential Market Effects Study*,<sup>2</sup> prepared for PG&E and SDG&E in March 1998, for additional context and background related to the net savings results analysis presented in this report.

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<sup>1</sup> PG&E's Table 6 is included in *Impact Evaluation of Pacific Gas and Electric Company's 1996 Residential Appliance Efficiency Incentives Program: High Efficiency Refrigeration*. PG&E Study ID #373-1. Prepared for PG&E by Xenergy, February 1998.

<sup>2</sup> *Residential Market Effects Study: Refrigerators and Compact Fluorescent Lights*. Prepared by Hagler Bailly for SDG&E and PG&E. March 1998. SDG&E Study ID #3902. PG&E Study ID #3302.

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## CHAPTER 2

### OBJECTIVES AND METHODOLOGY

#### 2.1 PURPOSE OF STUDY

This study was designed to produce a net-to-gross ratio applicable to the 1996 refrigerator rebate programs of SDG&E and PG&E for their first year load impact study. The methodology employed and described in this chapter was in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs" ("Protocols"), as adopted by California Public Utilities Commission Decision 93-05-063, revised January 1997, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, and 96-12-079.

#### 2.2 PROGRAMS EVALUATED

Both PG&E and SDG&E offered rebates for high efficiency refrigerators in 1996 under the umbrella of the Residential Appliance Efficiency Incentives (RAEI) program. A description of the utility programs included in this analysis is provided below:

##### 2.2.1 PG&E

PG&E offered two distinct programs to encourage the sale of energy efficient refrigerators in 1996. The Efficient Refrigerator Rebate Program offered rebates to residential customers for the purchase of efficient refrigerators. The program was implemented in the summer months of 1996 through local retailers. The Refrigerator Salesperson/Dealer Incentive Program (SPIFF) offered incentives to salespeople and dealers between October 1 and November 24, 1996. Table 2-1 presents the relationship between the percentage of energy savings beyond the current federal efficiency standards (established in 1993) to the incentive offered through both of these programs.<sup>1</sup>

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<sup>1</sup> *Annual Summary Report on Demand Side Management Programs in 1996 and 1997*, by PG&E, April 1997, page II\Res -3-4.

**Table 2-1: 1996 PG&E Refrigerator Program Incentive Levels**

	Percent Above 1993 Federal Efficiency Standards		
	20%	25%	30%+
Efficient Refrigerator Rebate Program	\$40	\$60	\$80
Salesperson/Dealer Incentive Program	\$10/\$3	\$15/\$5	\$20/\$8

### 2.2.2 SDG&E

SDG&E's refrigerator rebate program was offered throughout 1996. Table 2-2 presents the relationship between the percentage of energy savings beyond standards to the rebate offered.

**Table 2-2: 1996 SDG&E Refrigerator Program Incentive Levels (\$)**

Dates Offered:	Percent Above 1993 Federal Efficiency Standards:				
	15-19.99%	20-24.99%	25-29.99%	30-34.99	35-39.99%
9/26/93 - 2/14/96	\$50	\$75	\$100	\$125	\$150
2/15/96 - 2/14/97	\$25	\$50	\$75	\$100	\$125

## 2.3 METHODOLOGY

Our methodology was designed to yield a net-to-gross ratio and allow us to disaggregate total savings into savings attributable to true participants, free riders, and spillover. There were five steps associated with developing the net-to-gross ratio applicable to PG&E and SDG&E refrigerator rebate programs. A sixth step was necessary to disaggregate total savings into its component parts. The seventh and final step relates to estimating the level of precision for our net-to-gross ratio. These seven steps are:

1. Calculate the **total savings** from all refrigerators purchased in 1996 in California<sup>2</sup> (both rebated and non-rebated).
2. Determine the extent of **naturally occurring conservation** in 1996 in California.
3. Calculate **net savings** in 1996 in California by subtracting naturally occurring conservation (Step 2) from total California savings (Step 1).

<sup>2</sup> Throughout the report, when we refer to "California" it should be understood that we are referring to the service territories of SDG&E and PG&E only.



4. Collect the **gross savings** from rebated refrigerators from PG&E and SDG&E (which were calculated from program tracking records according to rules in Table C-3B of the Protocols).
5. Calculate the **net-to-gross ratio** by comparing net savings (Step 3) with gross savings (Step 4).
6. Disaggregate total savings to quantify the level of “**true program savings**”, “**free rider savings**” and “**spillover savings**.”
7. Estimate the net-to-gross **precision**.

The following sections describe the methodological processes employed for each of these analysis steps.

#### **Step 1: Total Savings from Refrigerators Purchased in 1996 in California**

Hagler Bailly implemented a random-digit dial phone survey of residential households in SDG&E and PG&E territories to estimate refrigerator purchase rates and efficiencies.<sup>3</sup> The survey included extensive screening questions to locate people who had bought new refrigerators in 1996 (they may or may not have been program participants). When we found refrigerator purchasers we asked them to read us their refrigerator model numbers and manufacturer names. By matching that data with the 1996 *Directory of Certified Refrigerators & Freezers* from the Association of Home Appliance Manufacturers (AHAM), we identified the exact size, type, efficiency, and electricity use per year of each refrigerator. Using formulas established by the current federal standards that refer to size and type of refrigerator, we calculated for each refrigerator the electricity it would have consumed if it consumed as much electricity as allowed in the current federal standards (which were established in 1993 and are in effect throughout the country). Comparing numbers from these calculations gives an estimate of the amount of electricity a given refrigerator saves compared to the federal standard. (This method is in compliance with Table C-3B of the Protocols.)

To determine the total savings from refrigerators purchased in 1996 in California, we first estimated the total number of refrigerators purchased in California in 1996 (both rebated and non-rebated) by multiplying the 1996 refrigerator purchase rate (determined through our customer survey) by the total number of households in California in 1996. Then, we multiplied the total number of refrigerators purchased in 1996 in California by the average per-unit savings

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<sup>3</sup> For a more extensive description of the methodology, see *Residential Market Effects Study: Refrigerators and Compact Fluorescent Lights*. Prepared by Hagler Bailly for SDG&E and PG&E. March 1998. SDG&E Study ID #3902. PG&E Study ID #3302.

over the 1993 federal standards for refrigerators purchased in 1996 in California. This gave us the estimate of the total savings in California compared to the federal standards.

**Step 2: Determine Extent of Naturally Occurring Conservation in 1996 in California**

Hagler Bailly implemented a random-digit dial phone survey of residential households in the United States (excluding California) to estimate refrigerator purchase rates and efficiencies using the same method as discussed in Step 1. This data represented the comparison area and provides us with an estimate of the level of naturally occurring conservation in California. Since some of the people surveyed in this method would have been in regions with utility refrigerator programs, this method gives us a conservative estimate of the level of naturally occurring conservation.

We multiplied the average per-unit savings for refrigerators purchased in 1996 in the comparison area by the total number of refrigerators purchased in 1996 in California to get an estimate of the level of naturally occurring conservation (NOC) in California.

**Step 3: Calculate Net Savings in 1996 in California**

Subtracting naturally occurring conservation (Step 2 results) from total savings in California (Step 1 results) gives us the total net savings in 1996 realized in California.

**Step 4: Collect 1996 Gross Program Savings**

PG&E and SDG&E provided 1996 refrigerator rebate program gross savings estimates for use in this analysis. Both utilities employed an engineering approach to calculate gross savings in accordance to rules in Table C-3B of the Protocols.

**Step 4A. PG&E Gross Impacts.** PG&E's estimates were developed in a separate impact evaluation and are reported in PG&E Study ID #373-1.

**Step 4B. SDG&E Gross Impacts.**

SDG&E's gross impacts were calculated using an engineering approach. This approach was validated by the CPUC and is consistent with the California Protocols for high efficiency refrigerator impact studies. Savings were based on data in SDG&E's 1996 Refrigerator Rebate Program tracking system. This database contains both the annual energy consumption and the federal annual energy consumption standards for each rebated refrigerator. SDG&E confirmed the consumption values by comparing them with data in CEC's Directory of Certified Refrigerators and Freezers.

SDG&E calculated total gross energy savings for each refrigerator by subtracting the model's annual energy consumption from the energy each model would have consumed if it were only as efficient as the current federal standards, using formulas based on its size and attributes. SDG&E

calculated its total energy savings by summing the annual energy savings for all rebate refrigerators.

SDG&E calculated total load impacts for each refrigerator by multiplying the average refrigerator load times a normalized refrigerator load factor applicable to the peak load hour of 1.34.<sup>4</sup> The average refrigerator load was calculated by dividing the gross energy impacts by 8,760 hours per year.

SDG&E calculated its gross energy and demand savings for their first earnings claim so no ex-post adjustment needed to be done for the current study.

**Step 5: Calculate Net-to-Gross Ratio**

The net-to-gross ratio is determined by dividing the net savings (Step 3 results) by gross savings (Step 4 results).

**Step 6: Disaggregation of Total Savings to Estimate True Program Impacts and Spillover**

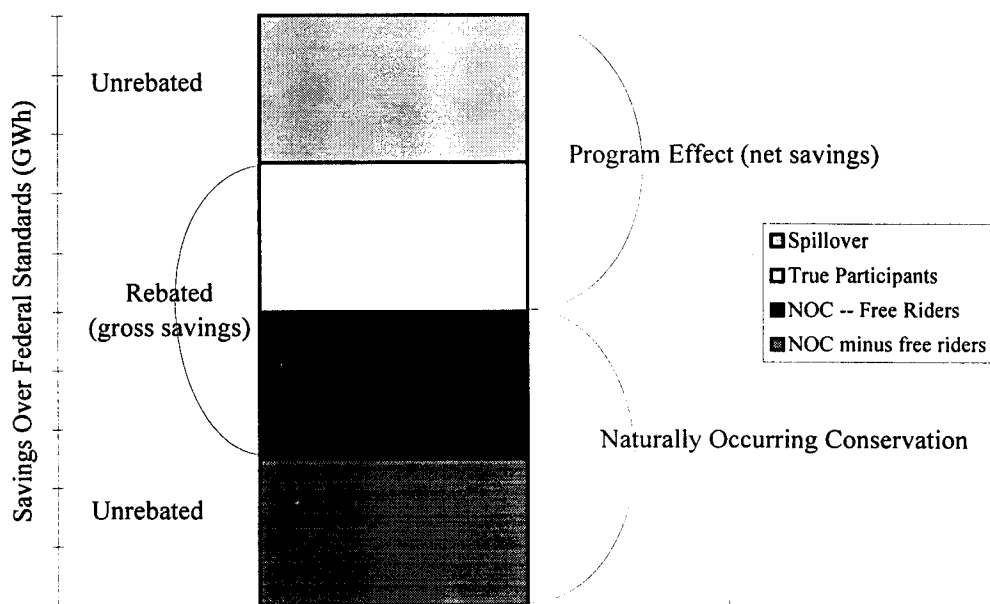
The total savings compared to federal standards of refrigerators in California is composed of four components:

1. Savings from true participants
2. Savings from free riders
3. Spillover
4. Un-rebated naturally occurring conservation (or total NOC minus free riders)

Figure 2-1 shows these components divided into equal parts. We will present another version of this graph in the next chapter with the actual results.

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<sup>4</sup> *Analysis of SCE and PG&E Refrigerator Load Data.* (Project 2052R). AAG & Associates, Inc. Prepared for the California DSM Measurement Advisory Committee, April 5, 1995.

**Figure 2-1: Components of Total Savings – Theory**

*(Components divided into equal parts for illustration only.)*

The total savings compared to federal standards (the entire bar) is comprised of two main pieces: 1) total program effects and 2) naturally occurring conservation. Savings from true participants and spillover represent the total program effect (the “Program Effect” semicircle in the graph). As we discussed above (Step 3), total program effects (net savings) are calculated by subtracting NOC from total savings.

Naturally occurring conservation (the “Naturally Occurring Conservation” semicircle in the graph and calculated in Step 2) is composed of savings from free riders and un-rebated NOC (purchases of high efficiency refrigerators that were not affected by the program and did not receive rebates). Free riders are part of NOC because they would have purchased the refrigerator without the rebate.

To further disaggregate total savings and allow us to calculate spillover, additional calculations were applied to the program effect semicircle and the NOC semicircle. For this study, we estimated the free rider component using a self-report survey. The free ridership rate allows us to fix the lower bound of the rebated semicircle, which allows us to calculate the amount of spillover. The math for this calculation is as follows:

Total rebated savings - free riders = true participants  
Total program effects - true participants = spillover

To measure the free-ridership rate, we implemented a separate survey of participants in the 1996 rebate programs (see Step 6a below). This free ridership rate was multiplied by the gross program savings to determine the level of "free rider savings".

#### **Step 6a: Calculation of Free Ridership Rate**

The free ridership rate for the 1996 programs was determined using a self-report survey of program participants, as follows:

- ▶ We completed a brief telephone survey with a total of 213 people who received refrigerator rebates for 1996 purchases ("participants") and asked a number of questions to determine the extent to which the program rebates influenced their purchase decisions.
- ▶ Based on participant responses to these questions, those who met at least one of the following criteria were not considered to be free riders (i.e., they were true participants):
  - Had not planned to buy a model of the same high efficiency level before hearing of the program rebate
  - Would not have paid the full price for the same high efficiency model of refrigerator if the rebate had not been available
  - Indicated that the rebate had at least some impact on their decision to purchase a high efficiency refrigerator (e.g., would not have purchased the same model without it, influenced the decision of when to buy new refrigerator, etc.)
- ▶ Of the remaining participants, respondents were classified as free riders if they reported that they:
  - Had planned to buy a model of the same high efficiency level before hearing of the program rebate
  - Would have paid the full price for the same high efficiency model of refrigerator regardless of the rebate
  - Indicated that the rebate had no impact on their decision to purchase a high efficiency refrigerator (e.g., would have purchased same model without it).
- ▶ There were a few participants who could not be classified as 100% free riders, but their responses indicated partial free ridership. We assigned them a free ridership rate of 50%.

It is commonly believed that self-report free ridership surveys overestimate actual free ridership levels. This survey was designed to minimize this problem but it should still be considered to produce a conservative net-to-gross ratio.

Table 2-3 presents the specific question wording and logic used to determine free ridership rates.

**Table 2-3: Free Ridership Question Wording and Logic**

Question Number	Question Wording	Skip Pattern and Free Ridership Determination Logic
F1	Had you planned to buy a model of same high efficiency level <u>before</u> you heard of the rebate?	NO – <i>not a free rider</i> YES/DK – ask F2
F2	Would you most likely have paid the full price for the same high efficiency model of refrigerator if the rebate had <u>not</u> been available?	NO – <i>not a free rider</i> YES – ask F4a DK – ask F3
F3	So, you are saying the rebate had no impact on your decision to purchase this high efficiency model of refrigerator?	NO/DK – ask F4a YES – <i>free rider</i>
F4a	Can you clarify for me in your own words what impact, if any, the rebate had on your decision to purchase that high efficiency model of refrigerator?	Open-ended question. <i>Verbatim responses used to determine free ridership.</i>

**Step 7: Estimate the Precision of the Net-To-Gross Calculations**

The precision estimate for the net-to-gross estimate was calculated using the same method used in the 1994 study with the following equation.<sup>5</sup>

$$\sigma_{\bar{x}_1 - \bar{x}_2} = \sqrt{s^2 \text{ pooled} \left( \frac{1}{N_1} + \frac{1}{N_2} \right)}$$

where:

$\sigma_{\bar{x}_1 - \bar{x}_2}$  = standard error of the difference

$S^2$  pooled = pooled variance estimate

$N_n$  = number of observations

The range of net savings = net savings estimate  $\pm \sigma_{\bar{x}_1 - \bar{x}_2} * t$

where

$t$  = critical value for  $t$  test at appropriate confidence interval.

The next chapter will present the results of the analyses completed in each of these seven steps. Chapter 4 includes a discussion of some of the issues that can help in interpreting the results.

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<sup>5</sup> Residential Appliance Efficiency Incentives Program High Efficiency Refrigeration: 1994 First Year Statewide Load Impact Study. SDG&E Study ID #914. Xenergy, Inc., prepared for Southern California Edison and SDG&E, February 1996.

## CHAPTER 3 RESULTS

This chapter presents the results of Hagler Bailly's net-to-gross analysis for PG&E and SDG&E 1996 refrigerator rebate programs. These results were derived using the methodology and the associated analytic steps described in Chapter 2. Results are presented below in Table 3-1 and discussed in more detail in the sections that follow.

**Table 3-1: Net Savings Analysis Results**

Analysis Step	Description of Analysis	Result
1	Calculate total yearly savings in California	44,767,630 kWh
2	Determine extent of naturally occurring conservation in California	24,284,386 kWh
3	Calculate net yearly savings by subtracting results of Step 2 from results of Step 1	20,483,244 kWh
4	Calculate gross savings from rebated refrigerators	15,697,025 kWh
5	Calculate net-to-gross ratio by dividing results of Step 3 into results of Step 4	130.49%
6	Disaggregate net savings results from Step 3:	
6a	Determine free ridership rate	23.7%
6b	Apply free ridership rate to disaggregate savings	
	Free Rider Savings	3,720,195 kWh
	True Participant Savings	11,976,830 kWh
	Spillover Savings	8,506,414 kWh

### **Step 1: Total Savings from Refrigerators Purchased in 1996 in California**

As discussed in Chapter 2, the total yearly savings from refrigerators purchased in 1996 in California (again meaning just SDG&E and PG&E territories) were estimated by matching model and manufacturer data provided by survey respondents with data from AHAM. On average, the typical refrigerator purchased in 1996 in California saved 108.5 kWh per year compared to the current federal standard.

The survey results produced an annual refrigerator purchase rate of 7.5% – that is, 7.5% of the households in California purchased a new refrigerator in 1996. Multiplying this number by the number of households in SDG&E and PG&E territories (5,502,918) yields an estimate of the



number of refrigerators purchased in California in 1996 (412,719). Finally, multiplying the per-unit savings by the number of refrigerators purchased gives us the estimate of the yearly savings in California when compared to the federal standards (44.8 GWh, or  $108.5 * 412,719$ ).

### **Step 2: Determine Extent of Naturally Occurring Conservation in 1996 in California**

The comparison area (which was the entire country minus the entire state of California) provides us with an estimate of the level of naturally occurring conservation in California. Using the same method employed for Step 1, we calculated the average per-unit yearly savings for refrigerators purchased in 1996 in the comparison area compared to the current federal standards (58.8 kWh). Multiplying this by the number of refrigerators purchased in California in 1996 gives us an estimate of the level of naturally conservation in California (24.3 GWh).

### **Step 3: Calculate Net Savings in 1996 in California**

Subtracting naturally occurring conservation (Step 2 result) from total savings in California (Step 1 result) gives us the total net savings attributable to the program (20.5 GWh).

### **Step 4: Determine 1996 Gross Program Savings**

Both PG&E and SDG&E 1996 refrigerator rebate program gross savings estimates were provided to us for use in this analysis.<sup>1</sup> Together, the utilities report a total of 15,697,025 kWh in gross program savings for 1996.

### **Step 5: Calculate Net-to-Gross Ratio**

The net-to-gross ratio is determined by comparing the net savings (Step 3 results) to gross savings (Step 4 results). The resulting ratio is 130.49%

### **Step 6: Disaggregation of Total Savings**

#### **Step 6a: Calculation of Free Ridership Rate**

Using the methodology described in Chapter 2, the free ridership rate for the 1996 programs was determined to be 23.7%. Table 3-2 presents the results of this determination. We assigned a free ridership rate of 0.5 to partial free riders (adding 0.7% to the free-ridership rate).

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<sup>1</sup> PG&E's estimates were developed in a separate impact evaluation and are reported in PG&E Study ID #373-1.

**Table 3-2: Free Ridership Rate Determination**

Category	Response	Number of Responses	Percent of Responses
Non-Free Rider	Did <u>not</u> plan on purchasing same model of refrigerator <u>before</u> hearing about rebate	107	50.2%
	Would <u>not</u> have paid full price for same model of refrigerator if rebate was <u>not</u> available	16	7.5%
	Rebate confirmed decision of which model to purchase	13	6.1%
	Would not have purchased same model without rebate	8	3.8%
	Rebate influenced decision of when to buy	4	1.9%
	Don't know if rebate would have influenced purchase decision	13	6.1%
		<b>161</b>	<b>75.6%</b>
Free Riders	Rebate did <u>not</u> influence purchase decision	34	16.0%
	Had not heard of rebate until survey	2	0.9%
	Would have purchased anyway, rebate was a "nice bonus"	13	6.1%
	<b>49</b>	<b>23.0%</b>	
Partial Free Rider	Rebate allowed purchase of larger unit with same efficiency level	2	0.9%
	Rebate was like a "reimbursement" to validate purchase	1	0.5%
	<b>3</b>	<b>1.4%</b>	

**Step 6b: Disaggregate Net Impacts**

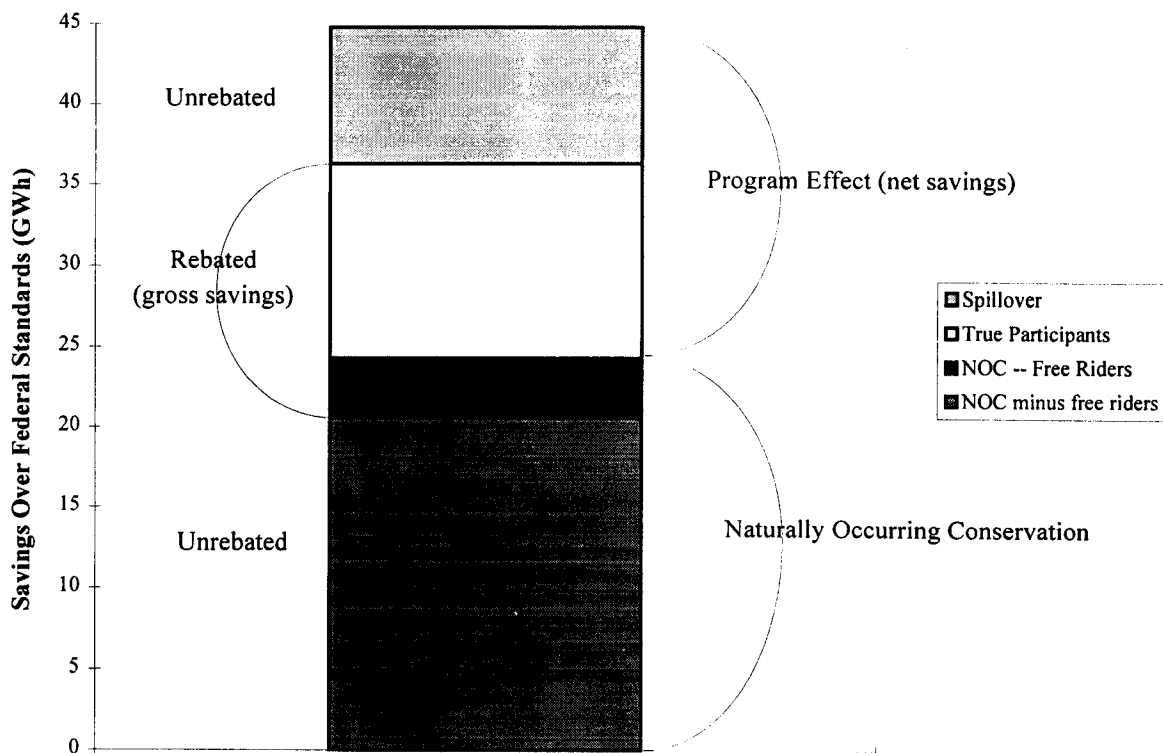
As described in Chapter 2, the total savings compared to federal standards of refrigerators in California is composed of four components (Figure 3-1):

1. Savings from true participants
2. Savings from free riders
3. Spillover
4. Un-rebated naturally occurring conservation (or total NOC minus free riders)

The free ridership rate derived from the analysis completed in Step 6a was found to be 23.7%. Multiplying this free ridership rate by the gross program savings produces about 3.7 GWh of "free rider savings." Subtracting these free rider energy savings from gross savings yields about 12.0 GWh of "true program savings" (or savings that were the result of the program's direct influence – the rebate). Subtracting the true participant savings from the net savings realized in California (Step 3 result) results in about 8.5 GWh in "spillover savings" (20.5 GWh - 12.0 GWh). Spillover savings represent the amount of savings realized in California (a) outside of the

direct influence of the utility rebate programs (i.e., unrebated purchases), and (b) over and above what would have naturally occurred in the market without the programs.

**Figure 3-1: Components of Total Savings**



**Step 7: Precision Estimate**

The analysis discussed above produced a net-to-gross ratio of 130.5%. Using the method described in Chapter 2, we calculated confidence intervals around the net-to-gross ratio. The 90% confidence interval around this number ranges from 191.6% to 69.3% (see Table 3-3). The 80% confidence interval around this number ranges from 178.2% to 82.8%.

**Table 3-3: Precision Estimate**

Description of Analysis	Per-Unit kWh	Number of Units	Total kWh	Net-To- Gross Ratio
Gross savings from rebated refrigerators			15,697,025	
Net savings	49.6	412,719	20,483,244	130.5%
90% Upper Bound	72.9	412,719	30,083,017	191.6%
90% Lower Bound	26.4	412,719	10,883,471	69.3%
80% Upper Bound	67.8	412,719	27,964,647	178.2%
80% Lower Bound	31.5	412,719	13,001,840	82.8%

(Note: The data used in the calculations have more decimals than shown in this table, as a result, multiplying per-unit kWh shown by the number of units shown will not result in the exact total kWh shown.)

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## CHAPTER 4

### DISCUSSION

This chapter presents a discussion of the methodology used in and the results of Hagler Bailly's net-to-gross analysis for the PG&E and SDG&E 1996 refrigerator rebate programs. This discussion is organized around two principal issues: (1) spillover results, and (2) free ridership results.

#### 4.1 SPILLOVER RESULTS

As reported in Chapter 3, we estimate approximately 45 GWh in energy savings were realized in California in 1996. Just over half of this amount "would have occurred anyway" due to naturally occurring conservation (54%). About 27% was a direct result of the utilities' rebate programs in 1996, and the remaining 19% represents spillover savings.

Another way of interpreting the spillover results is to think of gains in refrigerator efficiency over time in terms of "percent above federal efficiency standards". Our market effects research<sup>1</sup> found that although the number of rebates given in utility programs has declined over the years, the average efficiency of refrigerators sold through these programs relative to federal standards has steadily increased.

- ▶ In 1986, the efficiencies of refrigerators bought in California were not significantly different from those bought in the rest of the country.
- ▶ In 1991, the average refrigerator purchased in California was 10.2% more efficient than the 1990 federal standards, which was significantly higher than the 5.7% found in the rest of the country. We estimate that virtually 100% of the difference in average efficiency between the refrigerators sold in California and the rest of the country is accounted for by refrigerators sold through utility programs. Therefore, it appears that had the utilities not offered rebate programs in 1991, refrigerators purchased in California would have been similar to those purchased in the rest of the country.
- ▶ An assessment of the refrigerator rebate programs offered by Southern California Edison and SDG&E in 1994 concluded that the average efficiency of refrigerators purchased in

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<sup>1</sup> *Residential Market Effects Study: Refrigerators and Compact Fluorescent Lights*. Prepared by Hagler Bailly for PG&E and SDG&E. SDG&E Study ID # 3902. PG&E Study ID #3302. March 1998.

Southern California was also higher than the comparison area, and 100% of the difference in refrigerator efficiencies was attributable to the utilities' rebate programs.<sup>2</sup>

### **Factors Contributing to Spillover**

We speculate that a combination of factors have contributed to the magnitude of spillover savings observed in the 1996 refrigerator market, as discussed below.

#### Refrigerator Efficiency Standards

Refrigerator efficiency standards have been central to much of the changes in the industry over the past 10 years. California led much of the country by developing statewide refrigerator standards in 1987 and revising them for 1990. On November 17, 1989, the first federal refrigerator efficiency standards were set forth and they became effective on January 1, 1990. At that time, the federal standards were not as stringent as the statewide standards adopted in California for 1990. On January 1, 1993, the federal standards were revised and became consistent with the California statewide standards. These 1993 standards are still in force today.

#### Utility Program Incentive Design

California utilities have been working for many years to influence the production of refrigerators that are even more efficient than required by the relevant standards. Consistently each year, utilities have altered their incentive structure as the more efficient models became available on the market (as evidenced by increased participation levels for these higher efficiency models). In reaction to increased equipment availability and improved market demand, utilities would scale back the incentive amount for the earlier models, or eliminate the incentive altogether, and offer increased incentives for even higher efficiency models.

#### Market Reactions and Interactions

The changes in efficiency standards and utility incentive structures have led to several reactive and interactive effects within the distribution channel for refrigerators:

- ▶ “Market Push” – manufacturers have produced high efficiency refrigerators both to (a) comply with changing statewide/federal standards, and (b) capture the market demand created by utility rebate programs designed to encourage the adoption of even higher efficiency models.

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<sup>2</sup> *Residential Appliance Efficiency Incentives Program, High Efficiency Refrigerators, 1994 First Year Statewide Load Impact Report*. SDG&E Study ID #914. Xenergy, Inc., prepared for Southern California Edison and SDG&E, February 1996, page 4-2.

- ▶ “Market Pull” – increased consumer awareness and demand for higher efficiency refrigerators has served to influence both manufacturer production and retailer sales of these models.

Overall, these factors combined have contributed to the magnitude of spillover savings observed in the 1996 California refrigerator market.

## 4.2 FREE RIDERSHIP RESULTS

The methodology used by in the 1994 study<sup>3</sup> incorporated the effects of spillover and free ridership and did not produce estimates of these factors separately. Hence, from that research it was not possible to determine whether spillover and free ridership effects were small or large and were canceling each other out. Our study produced results using a methodology that was similar to Xenergy’s, but also calculated a separate free ridership rate which allowed us to determine the magnitude of spillover effects observed in the market. We were thus able to calculate the free ridership and spillover components of the net-to-gross ratio.

Our approach to determining the rate of free ridership was based on participants’ self-reported responses and was consistent with the Protocols and with the California DSM Measurement Advisory Committee (CADMAC) *Quality Assurance Guidelines* regarding procedures for using self-report methods. For example, we included “set-up” questions which were used to guide respondents through a process of establishing benchmarks against which to remember the decision making process. In addition, our survey instrument also made use of multiple questionnaire items to measure free-ridership and address inconsistencies.

Earlier studies of free ridership also included participant responses regarding whether or not they had compared energy efficiency levels and prices of refrigerators prior to learning of the rebate. While these questions were included in our survey, the responses were not used in the free rider calculation for the following reasons.

Based on discussions with both PG&E and SDG&E prior to implementing the survey, it was agreed that in some parts of the market for refrigerators, rebates may have created situations where customers have no choice but to purchase an energy efficient refrigerator for certain types and sizes of refrigerator. In such areas, we expect free rider rates will be higher. For example, in those areas, customers shopping for refrigerators with no interest in or knowledge of efficiency or rebates are likely to come across one model that fits their needs (e.g., size, features, color, etc.) – they decide to buy it (literally have no choice) and only then learn that there is a rebate for the

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<sup>3</sup> *Residential Appliance Efficiency Incentives Program, High Efficiency Refrigerators, 1994 First Year Statewide Load Impact Report*. SDG&E Study ID #914. Xenergy, Inc., prepared for Southern California Edison and SDG&E, February 1996.

model they have chosen. To be conservative, in this analysis we have counted these people as free riders although earlier methods would have classified them as non-free riders since they did not compare efficiency levels or price differentials. (The definition of these purchasers as free riders is complicated by the fact that even though they would have bought the energy efficient refrigerator without the rebate, without the effects of the utility program they would not have been forced to purchase the energy efficient refrigerator, and so are in this sense affected by the program and are not free riders.) Thus, we agreed that we would ask questions about comparing efficiency levels and price differentials as part of the "set-up questions", but would not use participant responses to these questions in the free rider calculations.



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**APPENDIX A**  
**M&E PROTOCOLS TABLE 6 FOR SDG&E\***

\* PG&E's Table 6 is included in *Impact Evaluation of Pacific Gas and Electric Company's 1996 Residential Appliance Efficiency Incentives Program: High Efficiency Refrigeration*. PG&E Study ID #373-1. Prepared for PG&E by Xenergy, February 1998.

**M&E PROTOCOLS TABLE 6 -- SDG&E**  
Residential Appliance Efficiency Incentive Programs  
Designated Unit of Measurement: Refrigerator  
ENDUSE: Residential Refrigeration

	5. A. 90% CONFIDENCE LEVEL				5. B. 80% CONFIDENCE LEVEL			
	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND
<b>1. Average Participant Group and Average Comparison Group</b>								
A. Pre-Install Usage:								
Pre-Install kW	PA	PA	PA	PA	PA	PA	PA	PA
Pre-Install kWh	PA	PA	PA	PA	PA	PA	PA	PA
Base kW	PA	PA	PA	PA	PA	PA	PA	PA
Base kWh	PA	PA	PA	PA	PA	PA	PA	PA
Base Therms	PA	PA	PA	PA	PA	PA	PA	PA
Base kW/ designated unit of measurement	PA	PA	PA	PA	PA	PA	PA	PA
Base kWh/ designated unit of measurement	PA	PA	PA	PA	PA	PA	PA	PA
Base Therms/ designated unit of measurement	PA	PA	PA	PA	PA	PA	PA	PA
B. Impact year usage:								
Impact Yr. kWh	PA	PA	PA	PA	PA	PA	PA	PA
Impact Yr. Therms	PA	PA	PA	PA	PA	PA	PA	PA
Impact Yr. kW/ designated unit	PA	PA	PA	PA	PA	PA	PA	PA
Impact Yr. kWh/ designated unit	PA	PA	PA	PA	PA	PA	PA	PA
Impact Yr. Therms/ designated unit	PA	PA	PA	PA	PA	PA	PA	PA
C. Average Net and Gross End Use Load Impacts								
A. i. Load Impacts - kW	0.0959	AVG NET	0.1251	AVG NET	AVG GROSS	AVG NET	AVG GROSS	AVG NET
A. ii. Load Impacts - kWh	176	PA	230	PA	PA	PA	PA	PA
A. iii. Load Impacts - Therms	0.0959	PA	0.1251	PA	PA	PA	PA	PA
B. i. Load Impacts/designated unit - kW	176	PA	230	PA	PA	PA	PA	PA
B. ii. Load Impacts/designated unit - kWh	176	PA	230	PA	PA	PA	PA	PA
B. iii. Load Impacts/designated unit - Therms	176	PA	230	PA	PA	PA	PA	PA
C. i. a. % change in usage - Part Grp - kW	PA	PA	PA	PA	PA	PA	PA	PA
C. i. b. % change in usage - Part Grp - kWh	PA	PA	PA	PA	PA	PA	PA	PA
C. i. c. % change in usage - Part Grp - Therms	PA	PA	PA	PA	PA	PA	PA	PA
C. ii. a. % change in usage - Comp Grp - kW	PA	PA	PA	PA	PA	PA	PA	PA
C. ii. b. % change in usage - Comp Grp - kWh	PA	PA	PA	PA	PA	PA	PA	PA
C. ii. c. % change in usage - Comp Grp - Therms	PA	PA	PA	PA	PA	PA	PA	PA
D. Realization Rate:								
D.A. i. Load Impacts - kW, realization rate	1.0	PA	1.0	PA	PA	PA	PA	PA
D.A. ii. Load Impacts - kWh, realization rate	1.0	PA	1.0	PA	PA	PA	PA	PA
D.A. iii. Load Impacts - Therms, realization rate	1.0	PA	1.0	PA	PA	PA	PA	PA
D.B. i. Load Impacts/designated unit - kW, real rate	1.0	PA	1.0	PA	PA	PA	PA	PA
D.B. ii. Load Impacts/designated unit - kWh, real rate	1.0	PA	1.0	PA	PA	PA	PA	PA
D.B. iii. Load Impacts/designated unit - Therms, real rate	1.0	PA	1.0	PA	PA	PA	PA	PA
<b>3. Net-to-Gross Ratios</b>								
A. i. Average Load Impacts - kW	1.3049	RATIO	69.3	RATIO	191.6	RATIO	82.8	RATIO
A. ii. Average Load Impacts - kWh	1.3049	PA	69.3	PA	191.6	PA	82.8	PA
A. iii. Average Load Impacts - Therms	1.3049	PA	69.3	PA	191.6	PA	82.8	PA
B. i. Avg Load Impacts/designated unit - kW	1.3049	PA	69.3	PA	191.6	PA	82.8	PA
B. ii. Avg Load Impacts/designated unit - kWh	1.3049	PA	69.3	PA	191.6	PA	82.8	PA
B. iii. Avg Load Impacts/designated unit - Therms	1.3049	PA	69.3	PA	191.6	PA	82.8	PA
C. i. Avg Load Impact based on % chg in usage in impact year relative to base usage in impact year - kW	PA	PA	PA	PA	PA	PA	PA	PA
C. ii. Avg Load Impact based on % chg in usage in impact year relative to base usage in impact year - kWh	PA	PA	PA	PA	PA	PA	PA	PA
C. iii. Avg Load Impact based on % chg in usage in impact year relative to base usage in impact year - Therms	PA	PA	PA	PA	PA	PA	PA	PA
<b>4. Designated Unit Intermediate Data</b>								
A. Pre-Install average value	PA	PA	PA	PA	PA	PA	PA	PA
B. Post-Install average value	PA	PA	PA	PA	PA	PA	PA	PA
<b>6. Measure Count Data</b>								
A. Number of measures installed by participants in Part Grp	NUMBER	PA	41,218	NUMBER	PA	PA	PA	PA
B. Number of measure installed by all program participants in the 12 months of the program year	PA	PA	PA	PA	PA	PA	PA	PA
C. Number of measures installed by Comp Grp	PA	PA	PA	PA	PA	PA	PA	PA
<b>7. Market Segment Data</b>								
	PA	PA	PA	PA	PA	PA	PA	PA

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## APPENDIX B

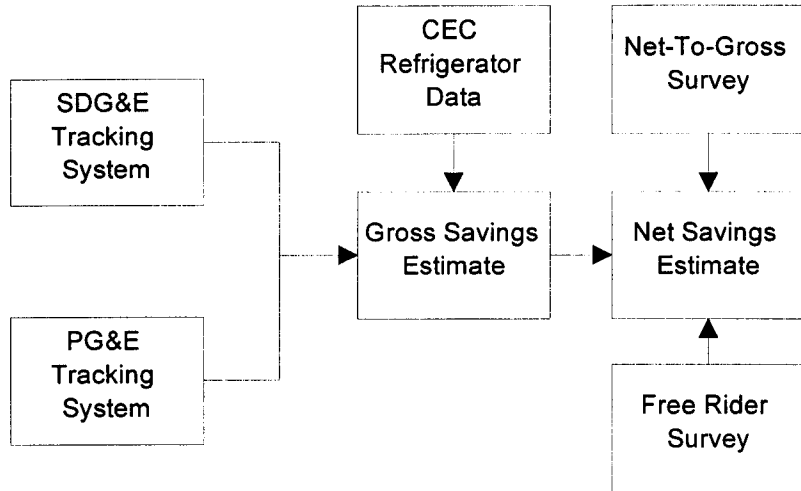
### M&E PROTOCOLS TABLE 7

#### A. OVERVIEW INFORMATION

1. **Study Title and Study ID Numbers:** Residential Appliance Efficiency Incentives Program: High Efficiency Refrigeration: 1996 First Year Statewide Load Impact Study: Net-To-Gross Analysis. SDG&E Study ID #980. PG&E Study ID #373-2
2. **Program, Program year (or years) and program description:** 1996 Residential Refrigerator Rebate Program. This program provided rebates for the purchase of refrigerators that consumed less energy than is allowable under federal appliance standards. The amount of the rebate offered depended on the rated energy consumption of the refrigerator relative to the current federal energy consumption standard for the refrigerator. See Chapter 2, Section 2.2 for details.
3. **End uses and/or measures covered:** The program covered new, high efficiency refrigerators for the residential sector.
4. **Methods and models used:** The methodology employed in this study is explained in Chapter 2.
5. **Participant and comparison group definition:** Program participants include all people who purchased high efficiency refrigerators and received rebates from SDG&E or PG&E in 1996. The comparison group was individuals who purchased refrigerators for their own, residential use in 1996 in the United States, excluding the entire state of California. Because the comparison group includes individuals who might have gotten a rebate, it leads to a conservative net-to-gross estimate.
6. **Analysis Sample Size:** The population of all participants rather than a sample was used for the gross savings calculations. The population included 78,442 high efficiency rebated refrigerators. The sample used for the self-report portion of the net-to-gross analysis was comprised of 213 participants in SDG&E and PG&E territories who purchased refrigerators in 1996. The survey that was used to measure spillover included 897 screening surveys in SDG&E territory, 1,022 in PG&E territory, and 2,011 in the rest of the country (minus all of California). The screening survey yielded energy efficiency data on 42 refrigerators purchased in SDG&E territory in 1996, 60 in PG&E territory, and 117 in the rest of the country.

**B. DATABASE MANAGEMENT**

**1. Flow chart illustrating relationship between data elements:**



2. **Specific data sources:** See Chapter 2, Section 2.3 of the report.
3. **Data attrition process:** See Chapter 2, Section 2.3 of the report.
4. **Internal/Organizational data quality checks and procedures:** Not applicable.
5. **Summary of data collected but not used:** Not applicable.

**C. SAMPLING**

1. **Sampling procedures and protocols:** See Chapter 2, Section 2.3, Steps 1 and 2.
2. **Survey information:** Appendix C provides the free rider survey instrument. The market effects survey also collected information used in this analysis, as well as information used for a separate study.<sup>1</sup> Random digit dialing screening calls were completed in 3,930 households (1,919 in California and 2,011 nationally). Respondents were asked if they purchased a refrigerator in 1986, 1991, or 1996. If they did, they were asked to read the model number and provide the manufacturer name. Valid refrigerator model numbers were collected for 102

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<sup>1</sup> See the following report for a complete discussion of the survey method and purpose: *Residential Market Effects Study: Refrigerators and Compact Fluorescent Lights*. Prepared by Hagler Bailly for SDG&E and PG&E. March 1998. SDG&E Study ID #3902. PG&E Study ID #3302.

refrigerators purchased in California in 1996 and for 117 purchased nationally. The difference between the 3,930 screening surveys and the 219 valid model numbers is composed of the following:

- Respondents who did not purchase a refrigerator in 1996.
- 1996 refrigerator purchasers who were unwilling or unable to find their refrigerator model number.
- 1996 refrigerator purchasers who provided refrigerator model numbers that could not be found in the 1996 *Directory of Certified Refrigerators & Freezers* published by the Association of Home Appliance Manufacturers (AHAM).

**Spillover Survey Attrition Table**

	SDG&E	PG&E	National	Total
Total Screening Surveys	897	1,022	2,011	3,930
Completed Refrigerator Surveys†				
1996	49	77	147	273
1991	59	59	122	240
1986	55	54	95	204
Total	163	190	364	717
Valid Refrigerator Model Numbers ‡				
1996	42	60	117	219
1991	49	40	77	166
1986	21	28	42	91
Total	112	128	236	476

† Purchased refrigerators in either 1996, 1991, or 1986. Fully completed surveys used in the market effects analysis, some additional partially-completed surveys were included in the market share analysis. The market effects analysis is reported in *Residential Market Effects Study: Refrigerators and Compact Fluorescent Lights*. Prepared for San Diego Gas & Electric and Pacific Gas & Electric by Hagler Bailly. March 1998. SDG&E Study ID #: 3902. PG&E Study ID #: 3302.

‡ Purchased refrigerators in either 1996, 1991, or 1986 and provided refrigerator make and model numbers that could be matched to AHAM data to obtain refrigerator characteristics and energy usage. These surveys were used in the market share analysis.

**Free Rider Survey Attrition Table**

	SDG&E	PG&E	Total
Starting Sample	215	190	405
No phone number	23	19	42
Ineligible †	13	2	15
Adjusted sample	179	169	348
Language Barrier	1	2	3
Refused	21	16	37
Unable to contact after 6 attempts	25	34	59
Completed surveys	103	110	213
Response rate ‡	57.5%	65.1%	61.2%

† Ineligible includes business numbers

‡ Computed as (completed surveys/adjusted sample)

3. **Statistical descriptions:** Not applicable.

#### **D. DATA SCREENING AND ANALYSIS**

1. **Procedures used for treatment of outliers, missing data points, and weather adjustments:** Respondents who did not provide refrigerator model numbers or who provided ones that could not be found in the AHAM database were re-called to attempt to collect valid model numbers. Collected model numbers were matched one-by-one with the 1996 AHAM refrigerator database. When exact matches could not be found the numbers were compared to other similar numbers of the same brand and manufacturer within the database. The first round of analysis considered clear character errors, omissions, or additions. The next round of analysis considered similar model numbers to identify characters, or strings of characters, that provided a clue to the energy use characteristics. In the final round of analysis, numbers that were not found in the booklet for the appropriate year were compared to numbers in the previous and succeeding years. Hand matching was required because small variations are often made to model numbers to indicate cosmetic differences between refrigerators and each variation of model number may not be represented in the AHAM data. For example, two refrigerators in the same brand and model may be different colors which would slightly change the overall model number. Because of all of the slight variations the model numbers were matched by hand to ensure proper identification. The matched model numbers are shown in Appendix D.
2. **Controlling for the effects of background variables:** See Chapter 4.
3. **Procedures used to screen data:** See Chapter 2, Section 2.3.

4. **Regression Statistics:** No regression models were used. Not applicable.
5. **Specification:**
  - a. No regression models were used. Not applicable.
  - b. No regression models were used. Not applicable.
  - c. No regression models were used. Not applicable.
  - d. No regression models were used. Not applicable.
  - e. No regression models were used. Not applicable.
6. **Error in measuring variables:** Not applicable.
7. **Autocorrelation:** Not applicable
8. **Heteroskedasticity:** Not applicable.
9. **Collinearity:** Not applicable.
10. **Influential data points:** Not applicable.
11. **Missing data:** See discussion under point one above.
12. **Precision:** See Chapter 3, Step 7.

#### **E. DATA INTERPRETATION AND APPLICATION**

The rationale for choosing this method is presented in Chapter 2, section 2.3.