Energy and Peak Demand Impact Estimates for DSM Technologies in the Residential and Commercial Sectors for California: Technical and Regulatory Perspectives

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This paper provides a technical discussion and regulatory perspective for a project conducted for the California Conservation Inventory Group (CCIG). This group, composed of the major utilities, regulatory agencies, and other environmental and research institutions in California has, for the past several years, initiated a series of projects designed to provide a comprehensive measurement and evaluation data base for demand side management technologies in the residential and commercial sectors. The project presented in this paper was undertaken to develop estimates of energy savings and peak demand impacts from the implementation of a host of DSM technologies in 16 commercial and two residential building types.

The analyses for this project were conducted primarily by simulation with the DOE-2.1E hourly building energy simulation program through the development of baseline prototypes for each building type and for three vintages and five climate regions in the state. Baseline estimates of end-use energy consumption were calibrated with the output from the California Energy Commission (CEC) and utility forecasting models. Simulation results were processed into a data base provided to the CCIG for inclusion in their Data base For Energy Efficient Resources (DEER). This data base contains information on technology costs, market share, measure life, and other data utilized in the measurement and evaluation activities associated with DSM planning. This paper also discusses the difficulties and compromises associated with both the technical analysis and the regulatory application of the results from this project and provides insight into the collaborative process from both perspectives.

Introduction

This paper is derived from, and presents a subset of, the results of a study sponsored by the California Conservation Inventory Group (CCIG) to estimate the energy and peak demand impacts associated with the installation of a large number of conservation technologies in residential and commercial buildings in California. The CCIG is a consortium that includes the California Energy Commission (CEC), the California Public Utilities Commission (CPUC), the State's major electric and gas utilities, as well as other organizations such as the Natural Resources Defense Council (NRDC), the California Institute for Energy Efficiency (CIEE), and the Lawrence Berkeley Laboratory (LBL). This consortium was born from the California Collaborative Process which, among other things, provided for expanded utility investment in Demand Side Management (DSM) activities including research and evaluation studies.

This project was one in a series of projects undertaken by the CCIG to develop a common understanding of the costs and benefits associated with the implementation of specific conservation technologies (through programs) in the residential and commercial sectors of the State. Previous projects included the development of a measure cost data base (Xenergy 1992), which contains estimates of purchase and installation costs associated with a large number of conservation technologies and measures. This study was designed to develop estimates of annual energy savings, coincident peak demand impacts, and time-of-use or load shape impacts associated with a subset of the technologies and measures examined in the previous study.

The overall approach to this study involved the following steps:

1. Collect the data for and establish baseline residential Unit Energy Consumption (UEC), commercial Energy Utilization Intensity (EUI), and average load shape information by building type, vintage, and climate region;

2. Collect and analyze data to establish base case residential and commercial building prototypes by building type, vintage, and climate region;

3. Simulate energy use from the base case prototypes (using the DOE-2.1 program) and reconcile the results with the baseline UEC, EUI, and load shape data for each building type, vintage, and climate region;

4. Screen an initial list of measures, and develop or select the appropriate methodology to analyze and quantify the energy savings, coincident peak demand impacts, and load shapes for each technology;

5. Develop programs to process, manage, and store the large amounts of input and output data associated with the estimation of the impacts for all measures;

6. Develop the parametric cases associated with the description and application of each measure to the appropriate building types, vintages, and climate regions; and

7. Utilize the base cases and parametric cases, the selected methodology, and the data processing and management programs to estimate the energy savings, coincident peak demand impacts, and load shapes associated with each conservation measure.

The term technology, as utilized in this paper, refers to a device which can be installed in residential or commercial buildings to alter the energy use characteristics for a particular end-use (economizer installation, for instance). The term measure is used to indicate an action or operating characteristic associated with the use or implementation of a particular technology in a building (refrigerator maintenance, for example). For brevity, these terms are utilized interchangeably.

Climate Regions and Weather Data

The technologies and measures examined can be generally classified into weather-sensitive and non-weather-sensitive categories. Weather-sensitive measures are defined as those which directly, or through interaction, affect the heating, cooling, and ventilation energy use characteristics of a building in response to the outdoor climate. Measures in this category generally include building shell and HVAC equipment technologies. In the commercial sector, indoor lighting is also included in this category, due to its effect on the HVAC loads. Conversely, non-weather-sensitive measures are those for which the impacts have little or no variation with climate.

For weather-sensitive measures, estimates of energy savings, coincident peak demand impacts, and load shapes were derived for five separate climate regions in California. These regions are defined as the North Coast, Central Valley, South Coast, South Inland, and Desert climate regions. In general, energy and peak demand impacts for weather-sensitive measures were developed for all five climate regions defined above. For non-weather-sensitive measures, impacts were developed using the North Coast and South Inland building prototypes to provide a reasonable representation of typical values for a subset of the regions defined.

Table 1 contains a mapping of the climate regions defined for this project to the climate zones utilized by the CEC Building Standards Office and the utility service areas included in these regions. The mapping shown in this table does not represent an exact match, as overlap and differences in definition exist between the climate zones utilized for building standards and for forecasting

Table 1. Mapping of CEC Climate Zones to Utility Service Areas

Climate Region	Building Standards Climate Zones	Utility Service Areas
North Coast	1,2,3,(4),5	PG&E
South Coast	6,(7),8	SCE, LADWP, SDG&E
South Inland	(9),10	SCE, LADWP
Central Valley	11,(12),13	PG&E, SMUD, SCE
Desert	14,(15)	SCE

purposes. The actual weather file utilized to represent each climate region is shown in parentheses. Selection of the appropriate weather file was made based on locating a file with intermediate average temperature information (minimum and maximum dry bulb, and heating and cooling degree days) within each region. Selection of the weather file was also based on correlating existing building density and new construction activity with the climate zone represented by the weather file.

Market Segments and Nomenclature

The technologies and measures examined during this project are applicable to the residential and commercial sectors. The market segments defined for each are shown in Figure 1, along with the abbreviations and keywords used to denote building type, vintage, and climate region.

Keyword	Building Type
SFAM	Single-Family Home
MFAM	Multi-Family Unit
SOFF	Small Office
LOFF	Large Office
SRET	Small Retail
LRET	Large Retail
SDRE	Sit-Down Restaurant
FFRE	Fast-Food Restaurant
GROC	Grocery Store
REFW	Refrigerated Warehouse
STOR	Non-Refrigerated Warehouse
HOSP	Hospital
NURS	Nursing Home
PRIM	Primary School
HIGH	Secondary School
COLL	College
HOTL	Hotel/Large Lodging
MOTL	Motel/Small Lodging

Keyword	Vintage
OLD	prior to 1978
T24	between 1978 and 1991
NEW	after 1991

Keyword	Climate Zone
NC	North Coast
SC	South Coast
SI	South Inland
CV	Central Valley
DR	Desert

Figure 1. Market Segments and Nomenclature

Development of Baseline Energy Use Estimates

The first step of the study was to develop estimates of baseline energy use by end-use for the various market segments (NEOS 1994a). The primary sources of data utilized to develop these baseline estimates were the input and output data sets from the CEC residential and commercial forecasting models. These data were selected as the primary source for the development of these estimates for several reasons:

- The CEC data were developed and available for 16 California climate zones representing seven forecast planning areas. This level of detail provided the ability to combine and average data from the different climate zones to represent the five climate regions of interest to this project in a consistent fashion;
- The CEC data were provided in sufficient detail to enable the estimation of the average UEC and EUI values for the vintages relevant to this project; and
- The project specifications emphasized consistency with the CEC forecast models during the comparison and reconciliation phases of the study.

Residential Baseline UEC Values

The residential models and data from all parties contain the assumption of appliance replacement and efficiency improvement resulting from the implementation of equipment standards. However, only central conditioning end-use appliances are related to housing vintage (as well as climate zone). As such, central heating and air-conditioning end-use UEC values were developed for the three housing vintages relevant to this project. These are pre-75 (or pre-standard), 1975 through 1991 (or Title-24), and post- 1991 (or new construction) housing vintages. Other conditioning and non-conditioning appliances are not related to housing vintage (or climate zone for non-conditioning end-uses), due to the portability of many of these appliances and the difficulty in obtaining data and estimation methodologies to relate housing and appliance vintage for these end-uses. To maintain consistency with the housing vintage definitions listed above, however, average UECs for all non-conditioning end-uses were estimated for the same vintages of appliance stock (pre-75, 1975-1991, and post-1991 appliance vintages). These estimates, however, were developed for each utility service area and for a statewide weighted average.

Non-conditioning appliance UECs for electricity and natural gas were also developed by appliance vintage for 14 end-uses in the single-family and multi-family building types. These appliances or end-uses include water heater, refrigerator, freezer, clothes washer, clothes dryer, dishwasher, oven/range, miscellaneous (plug loads and lights), color TV, water bed, pool pump, pool heater, spa pump, and spa heater. The latter two end-uses were estimated for single-family homes only. As indicated earlier the CEC and utility models do not forecast energy use from these appliances at the climate zone level, but only for the utility service area as a whole. UEC estimates for these appliances were, therefore, developed from the CEC data for each of the five major California electric utilities, as well as for a statewide average weighted by the number of appliances.

Commercial Baseline EUI Values

The commercial models for all parties, including the CEC, contain the assumption of appliance or end-use replacement within the vintaging and decay of the floor space. This assumption enabled the estimation of average EUI values for each end-use within each vintage in a process which involved several steps. A summary description of the major components of this work are listed below:

1. Estimation of the amount of floor space by climate region, building type, and vintage. During this step the floor space estimates and vintaging and decay algorithms contained in the CEC floor space forecasting model were utilized to develop estimates of the amount of floor space surviving in 1992, constructed prior to 1979 and from 1979 through 1991. These estimates were developed for each of the CEC forecasting climate zones and combined to represent the five climate regions specific to this study.

2. Calculation of the average end-use saturation by climate region, building type, and vintage. This step involved utilization of the input end-use saturation data files by climate zone, as well as the floor space data, to develop estimates of the end-use saturations at the climate region and vintage detail level specific to this study .

3. Development of end-use and total electricity and natural gas sales estimates by climate region, building type, and vintage. In this step the CEC commercial sales forecasts for 1992 were aggregated into the climate region and vintage categories specific to this project.

4. Estimation of the average EUIs. Calculation of the EUI values for pre-standard and post-standard construction vintages in 1992 was accomplished by dividing the end-use sales estimates developed in step 3 for each building and fuel type by the product of the floor space times the saturation of the same end-use for the climate regions specific to this project.

   The baseline average EUI values for the non-conditioning end-uses were calculated on a statewide average basis by weighting the EUIs by the amount of saturated floor space for each end-use in each climate region. Since the South Coast region represents the largest share of floor area among the five regions in this study, the resulting average non-conditioning EUIs are somewhat biased towards this region. However the variation in non-conditioning average EUI values among the five climate regions was not large to begin with and the resulting non-conditioning baseline average EUIs are considered representative of the data and assumptions contained in the CEC forecasting models. The average 1992 EUI estimates for the office equipment end-use were also adjusted to match the data and information resulting from a study conducted by LBL (Piette et al. 1991) to examine the present level and expected growth of office equipment energy use in the commercial sector. Although the results of this study were incorporated into the CEC and utility forecasts during the ER-92 forecast, adjustments and modifications to the office equipment growth rates during the revised forecast cycle caused the EUIs for this end-use to diverge from the results of the LBL study. For consistency, the baseline average EUI values for all vintages of commercial buildings were set to the values reported in the LBL study for the year 1992.

5. Development of new construction (post-91) average EUIs. The procedures outlined in steps 1 through 4 above were utilized to develop estimates of baseline average EUI values for pre- and post-standard vintages in the year 1992. The new construction (or marginal) average EUIs were also estimated from the input assumptions and output results of the CEC commercial forecasting model. The 1992 standards (which took effect on January 1, 1993) affect the heating, cooling, ventilation, and indoor lighting end-uses in all building types (except hospitals). The CEC model assumes a compliance rate with these standards which begins at a low rate in 1993 and ramps up over the course of several years to a maximum value of 80% compliance. To bypass the intermediate effects of the phase-in period associated with the implementation of the 1992 standards, the procedure outlined in steps 1 through 4 was repeated utilizing the year 2000 and the input and output data assumptions associated with the vintage block representing 1993 through 2000 as the post-91 period. The results of these analyses were used to represent the post-91 vintage baseline average EUIs for the four end-uses indicated.

6. Disaggregation of the average EUIs for six of the ten commercial building types. The CEC (and utility) forecasting models utilize 11 commercial building types (including a miscellaneous building type category) rather than the 16 building types specific to this project. This step of the process involved proportioning the average EUI estimates developed for six of ten commercial building types utilized by the forecasting models into the subcategories specific to this project. The building types for which this disaggregation was necessary are: restaurant (into fast-food and sit-down), retail (into small and large), warehouse (into refrigerated and non-refrigerated), school (into primary and secondary), health (into hospital and nursing home), and lodging (into large/hotel and small/motel).

   Disaggregation of the average EUIs was accomplished by the utilization of two data elements: 1) estimates of the share of total floor space attributable to each sub category by climate region, and 2) estimates of the ratios of end-use consumption per square foot for similar end-uses in each building type sub category (for example, the ratio of indoor lighting consumption per square foot in small retail buildings over indoor lighting consumption per square foot in large retail buildings). The methodology used to develop the disaggregated EUI estimates is, essentially, the reverse of the process utilized by LBL to aggregate the EUI estimates for these same building types during a study conducted for the CEC and SCE (Akbari et al. 1988 & 1991). The results of that project were the basis for the EUI input estimates to the CEC and SCE commercial forecasting models during the ER-92 forecast cycle.

Building Prototypes

This section discusses the development and DOE-2 simulation of the 18 building prototypes relevant to the study. The data sources and assumptions utilized for the residential building types are presented first, followed by the commercial sector.

Residential Sector Data Sources and Assumptions

The residential prototypes utilized for this project were derived from a project conducted for the CEC entitled, "Energy Use and DSM Measure Impacts in Prototypical Buildings" (ITEM 1993). The aforementioned effort was designed to provide the CEC with revised Unit Energy Consumption (UEC) estimates for the conditioning end-uses for use in the development of the long-term residential energy demand forecasts for the state. Single- and multi-family prototypes were developed for five vintages and 16 climate zones (Demand Forecasting Office climate zones). The five vintages correspond to pre-standards (pre 1975), three generations of residential building standards (75-78, 79-82, and 83-91), and a new construction or post-91 vintage. Extensive analyses were conducted to derive average characteristics for construction, building equipment, occupancy, and building operation for each vintage and climate region. Sources of data examined for this purpose include the most recent RASS (Residential Appliance Saturation Surveys) data sets from each utility, RECS (Residential Energy Consumption Surveys) data from the Energy Information Agency, NAHB (National Association of Home Builder) surveys from 1979 through 1991, and the Title-24 regulations and standards for residential construction.

Three vintages from five of the sixteen climate zones were selected to best meet the needs of the analyses relevant to the technologies and measures associated with this project. These were the pre-75 vintage to represent the pre-standards or OLD vintage, the 79-82 vintage (as an intermediate point) to represent the T24 vintage, and the post-91 vintage to represent the NEW vintage for this project. Five forecasting climate zone prototypes were selected which best match the climate regions associated with this project. A number of modification to the prototypes were necessary, however, to facilitate proper simulation of all end-uses, technologies and measures associated with this project. For example, the prototypes developed by ITEM Systems contained an aggregated internal load gain profile representing the sum of all heat to the space from appliances, lights, and people. The CEC project was designed to examine only conditioning energy use and did not require the derivation of any other appliance UEC values. For this project, however, it was necessary to disaggregate these profiles into the corresponding energy usage values and profiles for each appliance individually.

The residential prototypes were represented by a building with an equal amount of wall, window, door, and roof area facing each cardinal orientation. The prototypes, therefore, represent an average of building population in which homes are constructed facing every direction. The floor area, window area, roof area, wall area, and the number of occupants per home vary by climate region and by vintage. Residential prototypes were simulated alternately with a heat pump and a gas furnace/central air-conditioning unit. Average floor, window, roof, and wall areas for the single-family prototype are shown in Table 2. Detailed building descriptions and characteristics for the residential building prototypes are contained in NEOS (1994b).

Table 2. Single-Family Building Prototype Areas

Climate Zone	Old	Vintage T24	New	Old	Vintage T24	New
		Total Floor Area			**Window Area**	
North Coast	1591	1904	1900	223	219	239
South Coast	1528	2064	1975	238	260	385
South Inland	1636	1811	1924	214	290	308
Central Valley	1528	1704	1792	200	273	287
Desert	1555	1741	1793	267	244	330
		Roof Area			**Wall Area**	
North Coast	1164	1582	1470	1854	1848	1824
South Coast	1071	1382	1355	1778	1940	1741
South Inland	1340	1382	1412	1906	1699	1775
Central Valley	1321	1505	1632	1816	1627	1687
Desert	1562	1690	1542	1775	1687	1644

Commercial Sector Data Sources and Assumptions

Sixteen commercial building types were defined for the analyses relevant to the technologies and measures appropriate to this sector. Unlike the residential sector, no equivalent complete, or recent prototypes were located for the commercial sector with the level of detail required for this project. Prototypes for a subset of the building types were obtained from various sources, however, most required extensive modification prior to their use. For the majority of building types, estimates of building structural and equipment characteristics were derived from examination of available mail and on-site survey data. Insufficient regional and vintage detail in these data sources, however, resulted in the utilization of similar building prototype floor area and construction characteristics for all building locations and vintages. Insulation levels, glazing U-Values, and HVAC and other building equipment efficiency values, however, were modified by vintage to account for the effect of building and equipment standards. Five survey data sets were analyzed to determine the general characteristics of commercial buildings in California. These databases included an on-site survey (1986 PG&E Commercial Energy Use Survey) and four mail surveys (the 1988 PG&E Commercial Energy Use Survey, the 1988 SCE Commercial Energy Use Survey, and the 1988 and 1990 SDG&E Commercial Energy Use Surveys). Average floor areas derived from a subset of the mail survey data and the average building prototype areas utilized for this study are shown in Table 3. Detailed building descriptions and characteristics for all commercial building prototypes are contained in NEOS (1994b).

Methodology, Data Processing and Measure Evaluation

This section describes the methodology used to estimate the measure impacts, the data processing and management tools employed for the analyses, and the measure screening and evaluation steps taken.

Impact Estimation Methodology

The primary analysis tool for the development of the energy savings, peak demand impacts, and load shapes for the measures relevant to this study was the DOE-2.1 Hourly Building Energy Simulation model. The strength of the DOE-2.1 model lies in its simulation abilities for building HVAC systems and their interaction with other building loads. Technologies of this type comprise the largest portion of the measure cases associated with this study. In addition, the scheduling capabilities of the DOE-2 program were utilized in conjunction with engineering estimates and manufacturer's data to obtain estimates of the energy savings, peak demand impacts, and load shapes from the non-conditioning or non-weather-sensitive measures associated with this study.

Table 3. Commercial Building prototype Average Floor Areas

Building Type	Vintage	PG&E Mail Survey	SCE Mail Survey	SDG&E Mail Survey	Prototype Building
Large Office	Pre Stand.	173489	161178	N/A	175000
Large Office	Post Stand.	181860	187504	N/A	175000
Small Office	Pre Stand.	11585	4417	N/A	10000
Small Office	Post Stand.	10478	6224	N/A	10000
Large Retail	Pre Stand.	124384	189319	84724	120000
Large Retail	Post Stand.	95202	100281	443226	120000
Small Retail	Pre Stand.	11927	6305	5923	8000
Small Retail	Post Stand.	14412	8643	6932	8000
Sit Down Rest.	All	7223	7751	3725	4000
Fast Food Rest.	All	10450	3934	2371	2000
Grocery	All	15153	14195	N/A	15000
Ref. Warehouse	All	54950	34236	46363	50000
Storage	All	101724	49602	17575	70000
Hospital	All	236408	296558	227826	250000
Nursing Home	All	57693	53036	56103	60000
Primary School	All	41360	52048	56567	50000
High School	All	200545	109507	N/A	150000
College	All	289710	414545	307036	300000
Hotel	All	297407	197783	N/A	200000
Motel	All	124925	26794	N/A	30000

As indicated, the DOE-2 program is an hourly simulation program. The use of hour-by-hour weather data, compiled from historical records, gives the user of this program the flexibility to model building energy performance for analysis of annual energy use patterns, peak events, and hourly load profiles. The detailed building description capabilities of the program allows for modeling of building loads, lighting systems, mechanical systems, and other building equipment. Hourly scheduling capabilities for occupancy, lighting, equipment, and HVAC systems ensure that load profiles can be represented in detail. The program allows the modeling of many typical HVAC system configurations. DOE-2.1 is also capable of modeling many energy conservation strategies, including building envelope measures, energy efficient lighting, daylighting controls, high performance glazings, HVAC controls, central plant options and others. Simulation modeling with DOE-2.1, therefore, facilitated an efficient and reasonably accurate analysis of the large array of technologies and measures associated with this project.

The DOE-2 program is also capable, with its unique "functions" utility to model certain custom building features and equipment operation by modifying the operation of equipment routines or processes that are inherently part of the program code. For example, the performance curve for a high efficiency or variable speed drive chiller can be implemented to augment or replace the default performance curves in the DOE-2.1 program when necessary. The parametric capabilities of the DOE-2 program also facilitated the efficient modeling of the large number of measure cases involved in this study. The latest available version of the DOE2.1 model is the "E" version or DOE2.1E. This version was made available for use in this project prior to its official release (which occurred later during the project). This version of the DOE-2.1 program was used in order to take advantage of a number of enhanced features and additional end-use modeling capabilities which were particularly well suited to the needs of the project. In addition, custom algorithms and source code were added to the program (by J. Hirsch and S. Gates) to enable specific simulation of selected measures which were not explicitly modeled in DOE-2.1E. Examples of these measures include hot and chilled water reset controls, piping and duct losses, separate exhaust fan scheduling and the residential combined space and water heating (hydronic) system.

Data Processing and Management

The large number of measure cases, and the need to generate load shape information for each case, clearly indicated that proper and efficient processing and management of the huge amounts of input and output data was a critical component of this study. Pre-processor and post-processor software, in conjunction with the DOE-2.1E program, were utilized to facilitate this process.

Two separate data bases were developed for each building type. These are:

1. A summary file, which contains the energy and peak demand impact estimates relevant to each measure. The summary data include the measure description information, the definition of the building type, vintage, climate region, and fuel types affected, the total building and primary end-use baseline energy use, as well as the energy savings and peak demand impacts in relation to the base case specified for each measure in absolute terms and as a percentage of the base.

2. A load shape file, which contains the 36-day load shapes associated with each measure (average weekday, average weekend day and peak day for each month).

Technology Evaluation and Screening

The original CCIG measure list was composed of a total of 76 measures for the residential sector and 96 measures for the commercial sector, in addition to 36 residential and 56 commercial indoor and outdoor lighting measures. During this phase of the project, these residential and commercial conservation technologies and measures were examined in detail from several perspectives. These include:

- Definition and technical specifications of each measure;
- The proper base-case scenario for the development of energy and peak demand impact estimates;
- Cost-effectiveness of measures;
- Expected net increase in energy use or coincident peak demand;
- Other measures not included in the CCIG list, but which could be important to the study;
- Technological suitability and maturity; and
- Applicability of each measure.

During the measure evaluation phase of the project consideration was also given to the definition of a streamlined or simplified approach for the estimation of energy and peak demand impacts from indoor lighting technologies in the commercial sector. The list of technologies initially provided by the CCIG included a large number of separate bulb, ballast, and fixture technologies. Estimation of impacts for each of these technologies on an individual bases was deemed impractical for this project, due to the large number of cases required and the fact that many of the technologies were highly related in their application to begin with (e.g. fluorescent lamps and ballasts). Therefore, indoor lighting measure impacts in the commercial sector were estimated for groups of lighting technologies representing “packages” or “bundles” of measures applied to a base-case scenario.

First, the base case scenarios for each commercial building type and vintage were established by relating the lighting EUI and implied connected load to a distribution of lighting technologies in each zone of the building. Lighting technologies for these base cases were selected to match typical building type applications using survey data and engineering assumptions. Once the base-case indoor lighting technologies were established for each prototype case, a bundle of lighting measures representing a low, medium, and high connected load reduction were defined. Technologies and measures were selected for each reduction case to provide progressively advanced technologies while maintaining adequate lighting levels within each zone. Each of these cases was then simulated with the DOE-2 program (which also captured the interactive effects on the HVAC system) to produce estimates of energy savings and peak demand impacts for each “bundle”. While the technologies and measures assumed for each lighting case do not encompass all possible technologies and applications, this approach provides a reasonable range of lighting energy and peak demand impacts. Furthermore, this approach provides the means for the development of relationships between building the energy and peak demand impact estimates and the implied connected lighting load reductions. These lighting load reductions may be achieved using other individual or combinations of lighting technologies besides those assumed in this project.

Measure Impacts

This section provides a graphical representation of the electricity energy impact estimates for a subset of the cases examined during this study for a representative residential and commercial building type. Due to the large amount of data, it is not feasible to present all of the results in this paper. A full listing of the results for all building types, climate regions, vintages, and fuel types are contained in the summary and load shape data bases provided to the CCIG, as well as in the DEER data base housed at the CEC. Detailed descriptions of all measures and the assumptions behind the measure impact estimates are contained in NEOS (1994c).

Residential Sector Technologies and Measures

Figure 2 provides an illustration of the electricity energy impacts associated with the measures examined for the single-family building type in the North Coast climate region. Annual energy impacts in kWh per household are shown, from lowest to highest, for the OLD vintage (pre-standards) and for an electrically heated (heat pump) home.

Commercial Sector Technologies and Measures

Figure 3 provides an illustration of the electricity energy impacts associated with the measures examined for the large office building type in the North Coast climate region. Annual energy impacts in kWh per square foot per year are shown, from lowest to highest, for the OLD vintage (pre-standards). Natural gas is the heating fuel source assumed for this building.

Regulatory Perspective

The energy impact results from this study are combined with measure cost and measure lifetime estimates (developed from other studies). Three major uses are planned for these data:

1. A benchmark for assessing utility savings claims;
2. A primary data base for use in developing forecasts of remaining or achievable DSM potential; and
3. An organizing framework to allow for comparisons of program activity and cost-effectiveness across utility and state DSM programs.

In addition, the CEC will use these data to fulfill its statutory obligation to serve as a central repository of energy use and savings data and to provide this information to interested parties in an easily accessible format. Each of these purposes is discussed below.

Use of the Data as a Benchmark

The energy and peak demand impact estimates generated for the approximately 200 technologies included in the study can be used as a benchmark to assess the

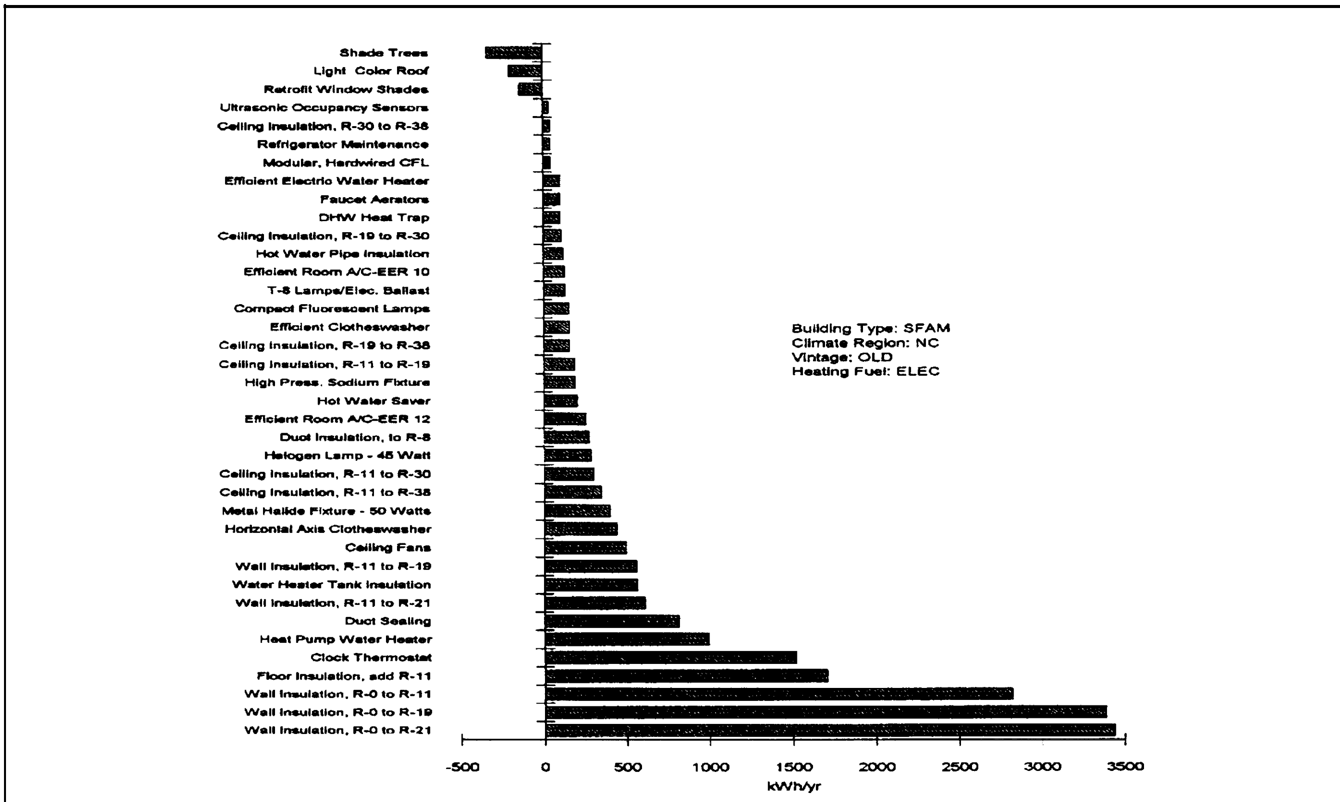

Figure 2. Measure Impacts for the Single-Family Prototype

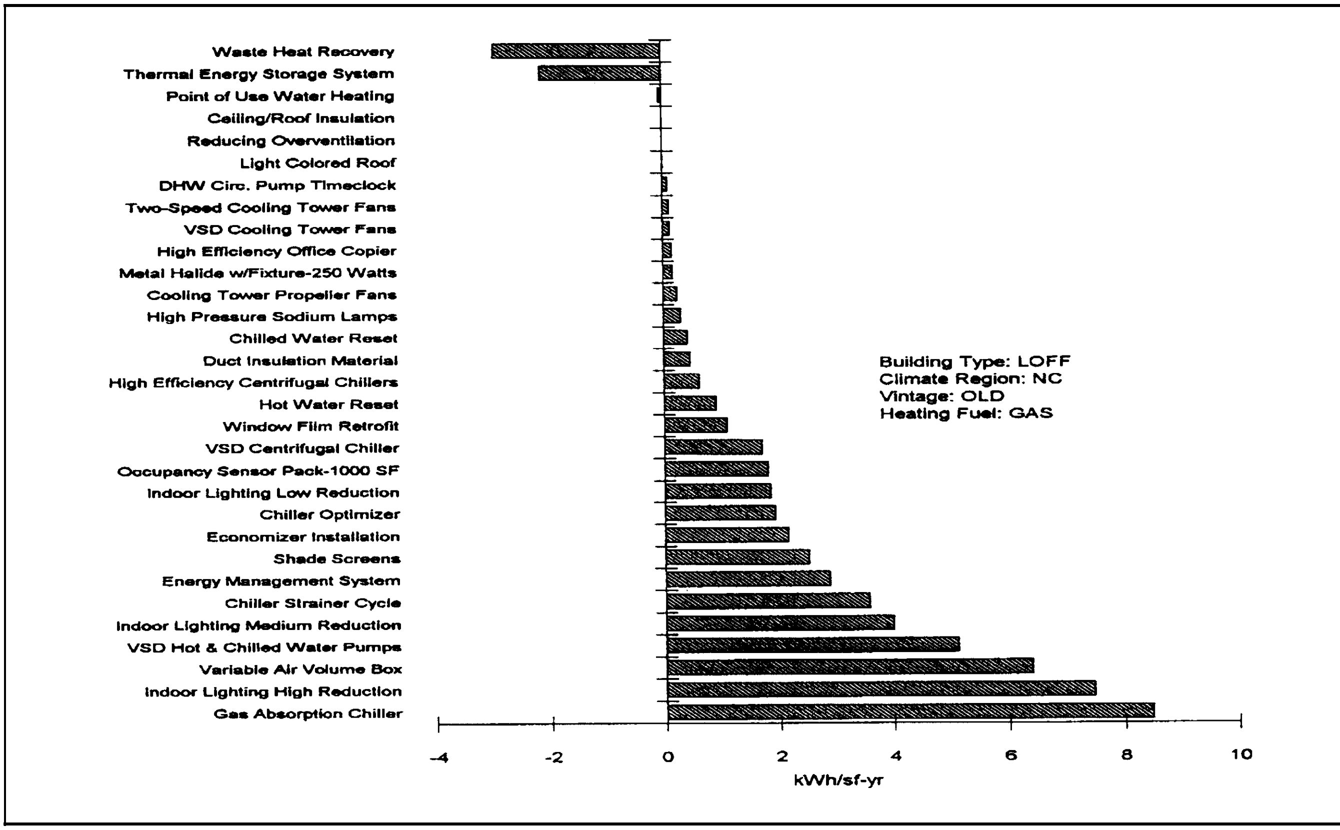

Figure 3. Measure Impacts for the Large Office Prototype

reasonableness of utility program and measure savings estimates. These estimates have more credibility than most "engineering-based" savings estimates, because they are explicitly linked to the CEC and utility long-term forecasting model UEC and EUI data for specific end-uses. They can also be used in assessing the differences in baseline energy use between a given set of program participants and the population average baseline energy use generated during this study. These baseline UECs and EUIs will be compared against the baseline values provided in utility program evaluation studies. Baseline estimates are a requirement of the Measurement And Evaluation protocols established by the CPUC. However, these measure impact estimates are not expected to exactly match the results from ex-post evaluation of program impacts, due to the considerable variation in human behavior and building structures that differentiate the real world from simulations based on building prototypes.

Use of the Data as a Primary Data Base for Developing DSM Forecasts

There are many parties that are interested in forecasts of DSM potential for a myriad of reasons. Utilities produce forecasts for resource and program planning purposes, while the state's Energy Commission is required, on a biennial basis, to identify the levels of conservation that are reasonably expected to occur. The regional air quality districts in California are interested in the use of conservation measures and programs as part of their implementation plans. In addition, the CCIG is required to produce estimates of the magnitudes and costs of remaining conservation resources on a biennial basis. The data from this study will serve as a building block for future efforts to identify future markets for energy service firms, local government agencies and public utilities.

Use of the Data as an Organizing Framework for Comparison Purposes

The DEER data base has been carefully designed to promote a standardized nomenclature and coding for all energy efficiency measures. This allows for comparison of both incremental cost, measure savings, and measure lifetime estimates for standardized technologies in similar building types and climate regions. Despite this planning, the energy savings or costs for some measures cannot be compared on a consistent bases, due to differences in assumptions regarding baseline energy use. Nevertheless, consultants, rate payer representatives, and interveners are particularly interested in making these types of comparisons. Care must be taken, however, to ensure that the cost, savings, and lifetime data are comparable (in terms of size, efficiency ratings, and other measure characteristics) for the application in question.

The CEC as a Central Repository for the Data

The California Energy Commission serves the function of managing and maintaining the DEER data base. Information on energy use trends from projects, such as the measure savings study, and from the CEC and utility filings are used to update the information in DEER for both public and private use. Utilities use this data base of information in regulatory filings, assessing program cost effectiveness, and as a source of information on emerging technologies. A beta test version of this data base was released in February with final release scheduled for June 1994. Currently the DEER data base contains information on incremental measure costs, energy and peak demand impacts, measure lifetime, installation rates, and measurement and evaluation studies performed on a standardized list of efficiency measures. The energy savings data generated from this study are expected to be in high demand and are accessible through a series of user friendly screens. The DEER serves a library function by allowing access to this type of information for a wide audience, and particularly smaller utilities who may not have the funds or skills to develop this type of information.

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