USING THE LONG-TERM INDUSTRIAL ENERGY FORECASTING (LIEF) MODEL TO ASSESS CORE INDUSTRIAL DSM POTENTIAL FOR SOUTHERN CALIFORNIA GAS COMPANY

Robert J. Mowris, P.E., Robert Mowris and Associates
Marc Ross, Ph.D., University of Michigan and Environmental and Informational Sciences Division, Argonne National Laboratory
Ron Kent, Senior Market Planner, Southern California Gas Company

INTRODUCTION

The industrial sector is very different from the residential and commercial sectors where building types, end uses, and DSM technologies are clearly defined. Industry uses hundreds of different processes, dozens of which are important for energy analysis. Unlike the residential and commercial sectors, truly generic technologies (like insulation, heat exchange, process heat, and heat recovery) describe less than half of the conservation opportunities. Because of the size and complexity of the industrial sector it is critical that utilities and planning agencies develop good analytical tools for forecasting energy demand and DSM potential. The Long-term Industrial Energy Forecasting (LIEF) Model is well suited for this purpose.

This paper provides an overview of the LIEF model, and an example of its use in forecasting DSM program savings potential for the core industrial market of Southern California Gas Company[1] (referred to as SoCalGas, SCG, or The Gas Company in this paper). Three 20-year forecast scenarios are developed for SCG's core industrial sector: (1) a base case scenario with no utility DSM programs; (2) a calibration scenario that only includes DSM programs from the current three-year General Rate Case; and (3) a 20-year DSM program scenario where DSM programs are assumed to continue beyond 1996 at reduced levels of spending.

As noted above, this paper only addresses the core industrial sector of SoCalGas' service territory. Core industrial customers are defined as those customers who have no alternative fuel use capabilities for their equipment and cannot risk curtailment or consume less than 2,880 million Btu (MMBtu) per month. Southern California Gas Company is at risk for noncore throughput and revenue. Therefore, SoCalGas does not offer DSM programs to its noncore customers. DSM is used here to define conservation, efficiency, fuel substitution, and load management programs. The LIEF model doesn't currently include fuel substitution measures in the same way that it includes conservation measures using the conservation supply curves. Therefore, fuel substitution measures are not considered in this study.[2]

THE LIEF MODEL

The 18-sector LIEF model is designed for convenient study of future industrial energy consumption, taking into account the composition of production, energy prices, and certain kinds of policy initiatives. Natural gas and electricity use can be modeled together or separately (the example provided in this paper is for natural gas only). Changes in energy intensity in each sector are driven by autonomous technological improvement (price-independent trend), the opportunity for energy-price-sensitive improvements, energy price expectations, and investment behavior. Although the LIEF decision-making framework involves more variables than the simplest econometric models, it enables direct comparison of an econometric approach with conservation supply curves from detailed engineering analysis. It also permits explicit consideration of a variety of policy approaches other than price manipulation.

The LIEF model incorporates some features of both "top-down" and "bottom-up" models.[3] (For thorough discussion of LIEF and other industrial forecasting models see Ross and Hwang 1992). The LIEF model doesn't explicitly model energy services. Instead, it relies on the concept that trends in aggregate energy demand are dependent upon: (1) Trends in production; (2) Sectoral or structural shift (e.g., changes in the mix of industrial output from energy-intensive to energy non-intensive sectors); and (3) Changes in real energy intensity due to technical change and energy-price effects as measured by the amount of energy used per unit of industrial output (Marlay 1984, Boyd et al. 1987, Doblin 1988, Howarth 1991).

The model's approach is to first properly disaggregate the industrial sector according to output growth rates and energy intensities. Real energy intensity trends are then combined with exogenous, macroeconomic forecasts of individual subsector growth rates and energy prices to yield forecasts of overall energy demand.

Figure 1 shows the factors affecting energy demand in LIEF. Sectoral energy intensity is affected by fundamental process efficiency and the adoption of energy conservation measures. Process efficiency is affected by naturally occurring autonomous technical change time trends associated with general progress in production technologies. The adoption of energy conservation measures is affected by energy prices, implicit capital recovery factors (*CRF*), and the conservation supply curves (CSC). Total production and sectoral production are used along with sectoral energy intensity to calculate total industrial energy use.

Table 1 provides an overview of the LIEF model equations. There are three primary modeling equations in LIEF. **Equation 1** is used to calculate total energy demand, $E_j(t)$. The effect of trends in total production is accounted for through summing economic production across all sectors. **Equation 2** is used to calculate sectoral changes in energy intensity, $EI_{ij}(t)$. The energy intensity from the previous timestep, $EI_{ij}(t\text{-}T)$, is multiplied by the complement of the penetration rate, $Pen(t)$, and the exponential decay function that accounts for naturally occurring autonomous technical change. This quantity is added to the penetration rate times the ideal energy intensity, $IEI_{ij}(t)$, for the current time step. **Equation 3** is used to calculate ideal energy intensity. The ideal energy intensity for the base year, $IEI_{ij}(t_o)$, is the actual base year energy intensity, $EI_{ij}(t_o)$, times (1-*Gap0*). This means for example, that if *Gap0* is 0.2, then the "gap" between ideal and actual base year energy intensity is 20 percent. The value of *Gap0* is determined by the fuel price. Higher fuel prices typically yield higher values of *Gap0*. The energy price function for the current time step relative to the base year is raised to the $-A_{ij}$ power. The "*A*" parameter is similar to a price elasticity and roughly corresponds to the slope of the CSC. In simple terms if *A* is 0.5, then a 1 percent price increase would yield a 2 percent energy savings. As in **Equation 2,** the exponential decay function accounts for naturally occurring autonomous technical change. This function decays very slowly since B_{ij} is small (typically less than 1 percent).

Proper description of production activities is a key to reasonable forecasting of industrial energy use. Changes in sectoral energy intensity can only be properly characterized if careful attention is paid to sectoral disaggregation as well as to data series. The choice of disaggregation can be more important to the forecast than the description of efficiency improvement.

The long-term energy forecasting technique rests on the following hierarchy of industrial decision making: (1) choice of fundamental production processes, which is autonomous in the sense that it is not sensitive to energy prices; (2) choice of energy-related technologies which is sensitive to energy price; and (3) operational decisions. It is assumed for long-term forecasting that operational decisions are not of interest. Thus, the modeling effort focuses on (1) and (2). For (2), the conservation supply curve is adopted as the basic analytical tool. This enables introduction into the model of variables apart from price, which provide useful policy-analysis handles.

Figure 2 illustrates how the conservation supply curve characterizes the Firm's economic perspective on improving energy efficiency.

Figure 1. Factors Affecting Energy Demand in LIEF, and External Considerations to the Model

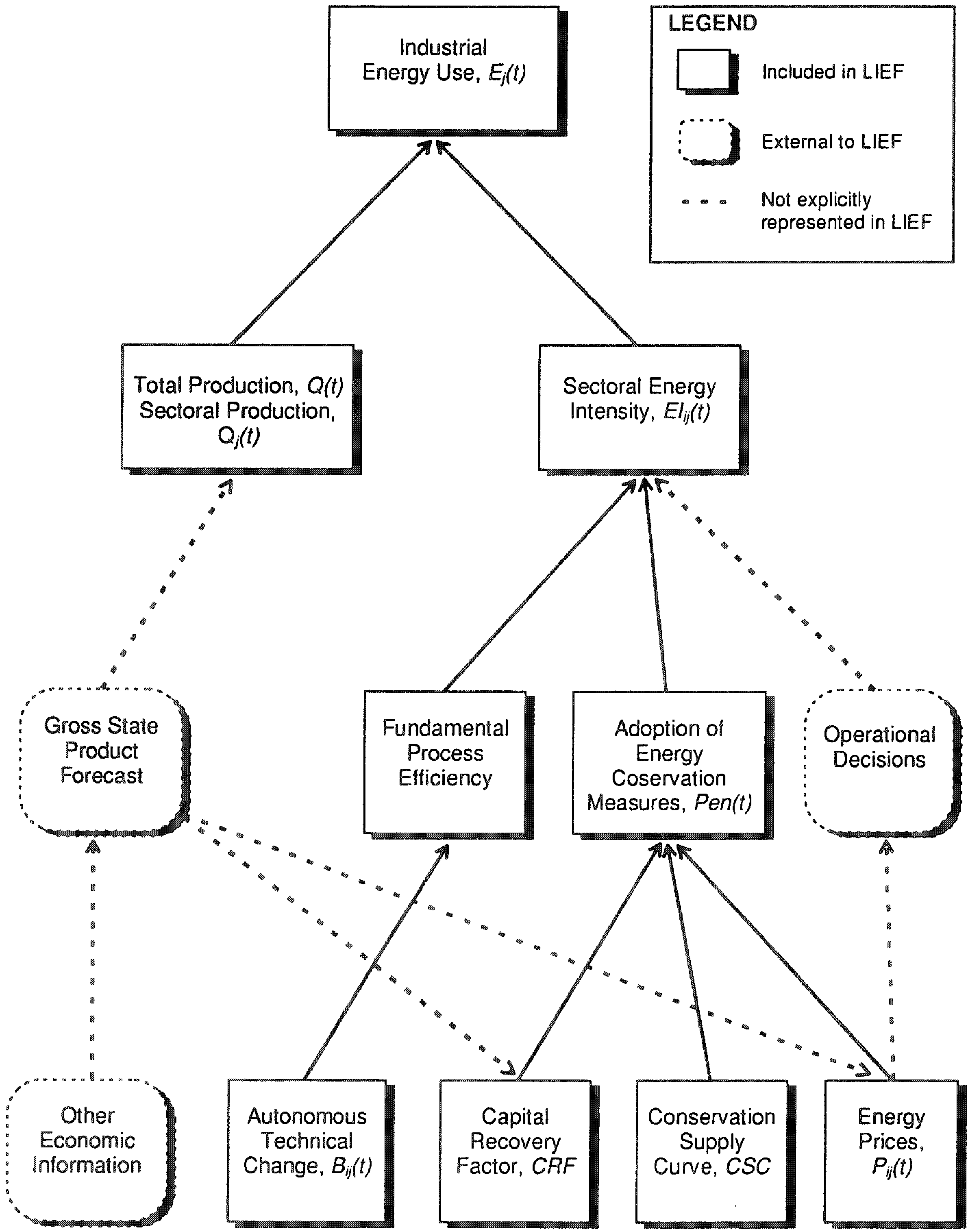


Table 1. Overview of LIEF Model Equations (simplified neglecting price-induced fuel-electricity substitution and recycling) (Ross and Hwang 1992, Ross et al. 1993)

Total Industrial Energy Demand

Eq. (1) $E_j(t) = \sum_{i=1}^{n} EI_{ij}(t)Q_i(t)$

where,

i = industrial sector,

j = energy type (natural gas or electricity);

$E_j(t)$ = total demand for energy type j;

$Q_i(t)$ = economic production in sector i; and

$EI_{ij}(t)$ = energy intensity of sector i for energy type j.

Energy Intensities by Sector

Eq. (2) $EI_{ij}(t) = EI_{ij}(t-T)[1-Pen(t)]\exp[-B_{ij}(t)T] + IEI_{ij}(t)Pen(t)$

where,

$Pen(t)$ = penetration rate of cost-effective, energy-price-sensitive conservation;

$IEI_{ij}(t)$ = ideal energy intensity from CSC for sector i and energy type j;

$B_{ij}(t) = B_{ij}(t_o)\{1-[(t-t_o)/(T\times Z_{ij})]\}$ = autonomous technical change (±);

Z_{ij} = number of time periods required for $B_{ij}(t)$ to equal zero;

T = length of one period for which forecasts are made;

Ideal Energy Intensity or "Smoothed" Conservation Supply Curve (CSC)

Eq. (3) $IEI_{ij}(t) = IEI_{ij}(t_o)\left[\frac{EP_{ij}(t)/CRF(t-T)}{P_{ij}(t_o)/CRF(t_o)}\right]^{-A_{ij}} \exp\left[-\sum_{i=0}^{N-1} B_{ij}(t_o+nT)T\right]$

where,

$EP_{ij}(t)$ = expected price of energy type j relevant to conservation at time t;

CRF = Capital Recovery Factor;

$P_{ij}(t_o)$ = price of energy type j in base year;

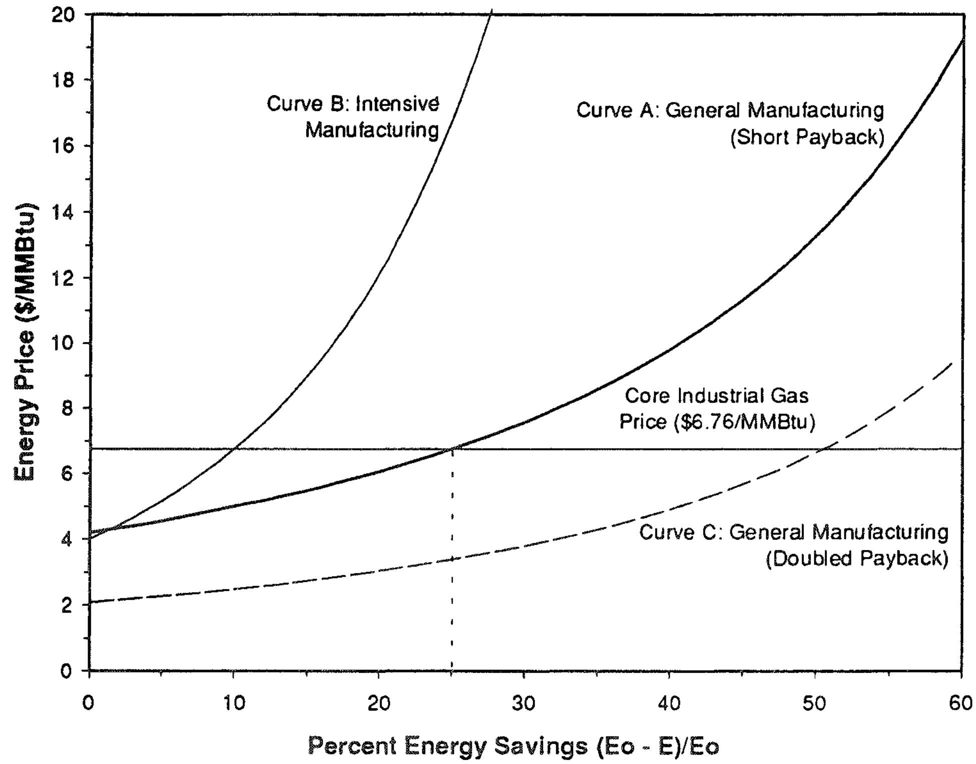
$A_{ij}(t)$ = price elasticity (roughly corresponds to slope of CSC);

$IEI_{ij}(t_o) = (1-Gap0_{ij})EI_{ij}(t_o)$

$Gap0$ = ideal energy savings at fuel price intercept of CSC;

$N = [(t-t_o)/T]-1$ = number of periods less one.

Figure 2. Conservation Supply Curves Characterize the Firm's Economic Perspective on Improving Energy Efficiency



Curve A shows that with present decision making criteria a 25 percent reduction might be cost-effective. The potential is usually less for energy-intensive industries where efficiency improvement has long had a high priority (Curve B). It is, however, greater if the energy prices and time horizons used in the decision making embody societal concerns (Curve C). For the residential and commercial building sectors, CSCs have been constructed on the basis of detailed lists of technologies (Meier et al. 1983, Koomey et al. 1991) The CSCs used in LIEF are less detailed. Historical analysis supplemented by some case studies of a few representative processes are used to generate representative CSC parameters.

The LIEF model is relatively easy to use in forecasting utility DSM savings given that adequate data is available to develop the base case inputs. The methodology or approach used for Southern California Gas Company's core industrial sector is provided in the next section.

USING LIEF TO ASSESS CORE INDUSTRIAL DSM SAVINGS POTENTIAL FOR SOUTHERN CALIFORNIA GAS COMPANY

Southern California Gas Company is interested in forecasting both aggregate core industrial DSM savings as well as savings within industrial sectors targeted for DSM programs. This is accomplished by aggregating core industrial natural gas demand by Standard Industrial Classifications (SIC) into the LIEF sector designations. **Table 2** shows both core and noncore industrial natural gas demand for 1993. The core market consumed 29.12 Trillion Btu (TBtu) in 1993 or 12 percent of the total (core plus noncore[4]). **Table 2** shows the core industries organized into twelve LIEF sector designations. Within the core market, General Manufacturing is the largest LIEF sector with 16 TBtu (55%). Fast Growing Manufacturing (sector 2) is the second largest LIEF sector with 3.3 TBtu (11.5%). Iron and Steel (Metals) are third with 2 TBtu (7%), Chemicals are fourth with 1.9 TBtu (6.4%), and Stone, Clay and Glass (Glass/Clay) are fifth with 1 TBtu (3.5%). These five LIEF sectors comprise 83.4% of total core demand, and are the "target" sectors for Southern California Gas Company's Industrial DSM programs.

Southern California Gas Company has two industrial DSM programs: the Industrial Energy Efficiency Incentives (IEEI) Program and the Industrial Energy Management Services (IEMS) Program. The IEMS program is an audit program with no specific efficiency measures. The IEEI program includes seventeen generic efficiency measures. **Table 3** provides an overview of the IEEI program, and **Table 4** provides an overview of the IEMS program. Unit savings estimates for these programs are based on load impact studies for actual measure installations and engineering estimates (SCG 1994). The list of measures shown in **Table 3** are somewhat generic and by no means comprehensive. The list might represent only one-half of the total opportunities.

Table 5 shows the LIEF input assumptions for Southern California Gas Company's core industrial sector. Sectoral production growth rates and production data were scaled from total industrial production data for the Southern California Gas Company service territory using data from the California Energy Commission and SCG (CEC 1992, SCG 1993a). LIEF defaults were used to model autonomous technical change time trends, recycle rates, and CSC parameters (*Gap0* and *A*) (Ross and Hwang 1992, Ross et al. 1993).

Figure 3 shows CSCs for the five largest LIEF sectors (1, 2, 5, 7, and 8). For illustrative purposes **Figure 3** also shows a CSC developed from IEEI program data[5] using a 33 percent CRF. The CRF represents the Firm's internal rate of return used for assessing the economics of energy-related investments. The IEEI program CSC assumes that a "real" program of measures would be similar in terms of costs and savings and reach a savings level of 30 percent. **Figure 4** shows the step function CSC created using the IEEI data given in **Table 3**. The upper CSC step function is plotted using a 33 percent CRF while the lower CSC step function is plotted using a 17 percent CRF. Utility DSM incentives typically pay one-third to one-half of the marginal cost of conservation measures, and this reduces the Firm's simple payback. This is modeled in LIEF by reducing the CRF. DSM incentives essentially raise the value of *Gap0* from 0.3 to 0.4 while the value of *A* stays constant at 0.3. As stated above, *Gap0* is roughly equivalent to the complement of the y-intercept of the CSC. In terms of the LIEF model, raising *Gap0* will lower the CSC making conservation measures economically more attractive to the Firm.

Three 20-year forecast scenarios are developed for SCG's core industrial sector: (1) a base case scenario with no utility DSM programs; (2) a calibration scenario that only includes DSM programs from the current three-year General Rate Case (SCG 1993, SCG 1994); and (3) a 20-year DSM program scenario where DSM programs are assumed to continue beyond 1996 at reduced levels of spending.

The base case scenario is calibrated to match the non DSM forecast provided by SoCalGas' forecasting staff. For the base case, CRFs for all sectors are maintained at 33 percent for the entire forecast period (Ross et al. 1993). Base case penetration rates are essentially identical to the LIEF default values. The LIEF defaults were developed by Ross and Hwang using an econometric "best" fit to historical data (Ross and Hwang 1992).

The calibration scenario is used to calibrate the LIEF sector CRF values and penetration rates to the current Test Year 1994 General Rate Case (TY94GRC). The TY94GRC includes DSM programs planned for 1994, 1995, and 1996. TY94GRC industrial DSM program savings goals are shown in **Tables 3** and **4**. The calibration scenario assumes that program goals remain constant from 1994 through 1996. Programs are assumed to stop after year 1996. This is modeled in LIEF by using a 17 percent CRF for 1994 through 1996, and a 33 percent CRF thereafter. Penetration rates are increased to 5.75 percent for 1994 through 1996, and the LIEF defaults are used thereafter.

The 20-year DSM program scenario assumes programs remain active for the entire 20-year period with reduced levels of spending and penetration after 1996. The 20-year DSM program scenario assumes CRF values are reduced from 33 percent to 17 percent for the entire forecast period for sectors 1, 2, 5, 7, and 8. **Table 6** shows the DSM penetration rates for all sectors. Penetration rates for sectors 1, 2, 5, 7, and 8 are set at 5.75 and 2.6 for 1994 through 1998 and then allowed to ramp down thereafter. From 2007 though 2013 the DSM penetration rates are two times higher than the LIEF defaults used for the other sectors.

Table 2. Core and Noncore Industrial Gas Use for Southern California Gas Company (1993)

SIC Code	Description	1993 Core *Trillion Btu*	%	LIEF Sector	LIEF Description	1993 Noncore *Trillion Btu*	%
20X	Food Products	3.16	10.86	1	General Manufacturing	12.22	5.71
21	Tobacco Products	0.00	0.00	1		0.00	0.00
203	Preserved Fruits, Vegetables	2.33	8.01	1		9.01	4.21
22	Textile Mill Products	1.94	6.65	1		4.17	1.95
23	Apparel, etc.	0.79	2.71	1		0.00	0.00
24	Lumber, Wood Products	0.10	0.33	1		0.64	0.30
25	Household Furniture	0.52	1.77	1		0.12	0.06
26X	Paper and Allied Products	0.20	0.69	1		7.54	3.52
30X	Plastic Products	0.34	1.16	1		0.40	0.19
31	Leather, Leather Products	0.01	0.03	1		0.00	0.00
34	Fabricated metal	2.91	9.98	1		4.40	2.06
35X	Misc. Comm./Ind. Equip.	0.84	2.87	1		0.15	0.07
36X	Misc. Elec. Equip.	0.70	2.40	1		0.34	0.16
37	Motor Vehicle, Aircraft	1.73	5.94	1		4.92	2.30
39	Misc. Manuf. Industries	0.46	1.59	1		0.00	0.00
	Subtotal	16.01	54.99			43.91	20.51
27	Printing, Publishing	0.83	2.86	2	Fast Growing Manufacturing	0.56	0.26
307	Rubber, Plastics	0.83	2.85	2		0.99	0.46
357	Computer, Office Equip.	0.26	0.88	2		0.05	0.02
366	Communications Equip.	0.41	1.42	2		0.20	0.09
367	Electronic Equip.	0.44	1.51	2		0.21	0.10
38	Measurement Instruments	0.56	1.91	2		0.18	0.08
	Subtotal	3.33	11.44			2.19	1.02
261	Pulp Mills	0.54	1.84	3	Paper and Pulp	20.02	9.35
2900	Crude Oil Refining	0.85	2.93	4	Petroleum	48.28	22.55
32X	Stone, Clay, Glass	0.51	1.77	5	Stone, Clay, Glass	4.48	2.09
3210	Flat Glass	0.51	1.75	5		4.43	2.07
3220	Glass, Glassware	0.00	-	5		0.00	-
	Subtotal	1.02	3.51			8.92	4.16
3241	Cement	0.10	0.34	6	Cement	0.86	0.40
33	Steel, Metal	2.04	7.01	7	Iron and Steel	10.62	4.96
28	Chemicals	1.86	6.40	8	Chemicals	9.29	4.34
1	Crops, Farming	1.36	-	9	Agriculture	0.99	-
2	Livestock	0.53	-	9		0.01	-
7	Agricultural Services	0.68				0.52	
8	Forestry	0.01				0.00	
9	Fishing, Hunting, Trapping	0.02				0.01	
494	Urban Water Pumping	0.00	-	9		0.00	-
497	Irrigation	0.00	-	9		0.00	-
	Subtotal	2.60	8.94			1.53	0.72
1040	Gold	0.01	-	10	Mining	0.00	-
1420	Crushed Stone	0.01	0.03	10		0.18	0.08
	Subtotal	0.02	0.05			0.18	0.08
1300	Petroleum and Natural Gas	0.32	1.11	11	Oil and Gas Extraction	67.69	31.62
1500	Construction	0.12	0.40	12	Construction	0.12	0.05
1600	Heavy Construction	0.10	0.35	12		0.10	0.05
1700	Special trade Contractors	0.19	0.65	12		0.19	0.09
	Subtotal	0.41	1.40			0.41	0.19
	Total	29.12				214.08	

Table 3. Industrial Energy Efficiency Incentives Program Summary

Measure Number	Description	First-Year Savings *MMBtu*	Unit Cost *$*	Total Units *-*	Total Annual Savings *MMBtu*	Total Cost *$*	Life *Years*	Cost of Saved Energy (CRF = 17%) *$/MMBtu*
1	Pipe Insulation	340	728	25	8,662	18,548	15	0.40
2	Burner Replacement	518	2,551	14	7,086	34,877	15	0.92
3	Tank Insulation	201	1,032	26	5,159	26,462	15	0.96
4	Process Modernization	468	2,984	16	7,488	47,744	25	1.11
5	Process Steam	803	5,569	24	19,585	135,829	25	1.20
6	Heat Recovery - Economizer HX	2,100	16,268	18	38,000	294,345	25	1.34
7	Heat Recovery - Regeneration	8,688	84,298	3	28,000	271,682	25	1.68
8	Process Hot Water	261	2,748	10	2,651	27,950	15	1.98
9	Heat Recovery - Recuperative HX	6,355	86,816	3	17,500	239,061	25	2.37
10	Heat Recovery - Recirculation	2,650	40,776	2	4,000	61,546	25	2.67
11	Process Dryer	577	10,495	8	4,372	79,508	25	3.15
12	Process Hot Water- Condensing	596	10,472	4	2,287	40,167	15	3.30
13	Burner Replacement - O2 Trim	711	13,000	1	930	17,024	15	3.44
14	Process Furnace/Kiln/Oven	302	6,299	23	7,010	146,013	25	3.61
15	Process Cooking	376	10,374	17	6,266	172,785	20	4.90
16	Process Heater/Tank/Washer	339	12,410	2	679	24,880	25	6.35
17	Thermal Oxidizer/Fume Incinerat	580	22,208	2	1,117	42,726	25	6.64
	Total				160,792	1,681,145		

Table 4. Industrial Energy Management Services Program Summary

Measure Number	Description	First-Year Savings *MMBtu*	Unit Cost *$*	Total Units *-*	Total Annual Savings *MMBtu*	Total Cost *$*	Life *Years*	Cost of Saved Energy (CRF = 17%) *$/MMBtu*
1	Industrial Audit	100	385	1,250	125,000	481,668	3	1.74

Table 5. LIEF Input Assumptions: SoCalGas Core Industrial Sector

Sector Number	Description	1993 Gas Demand *TBtu*	1993 Sectoral Production *$ Billion*	CSC Y Intercept Gap0 *-*	CSC Slope A *-*	Autonomous Technical Change Time Trend *-*	Average Production Growth Rate *%/Year*	Recycle Ratio *%/Year*
1	General Manufacturing	16.013	30.08	0.2000	0.4000	0.0054	1.0000	0.00
2	Fast Growing Manufacturing	3.331	2.86	0.2000	0.6000	0.0001	1.7500	0.00
3	Pulp and Paper	0.536	0.5	0.1500	0.2000	0.0250	2.0000	26.00
4	Petroleum Refining	0.853	0.23	0.1500	0.2000	0.0030	0.5000	0.00
5	Glass, Clay	1.023	0.124	0.1000	0.2500	0.0036	0.5950	11.00
6	Cement	0.099	0.026	0.2000	0.2000	0.0000	0.1120	0.00
7	Metals	2.041	0.4	0.1000	0.2000	0.0072	1.3670	42.00
8	Organic Chemicals	1.863	0.95	0.1500	0.2000	0.0000	2.5210	1.00
9	Agriculture	2.6	0.37	0.2000	0.5000	0.0000	0.9130	0.00
10	Mining	0.016	0.0064	0.2000	0.5000	0.0002	0.4860	0.00
11	Oil and Gas Extraction	0.323	0.006	0.2000	0.5000	-0.0150	-0.4320	0.00
12	Construction	0.407	3.33	0.2000	0.5000	0.0000	1.0000	0.00
	Total	29.105	38.8824					

Figure 3. Comparison of Industrial Energy Efficiency Incentives Program (IEEIP) and LIEF Sector Conservation Supply Curves for Core Industries

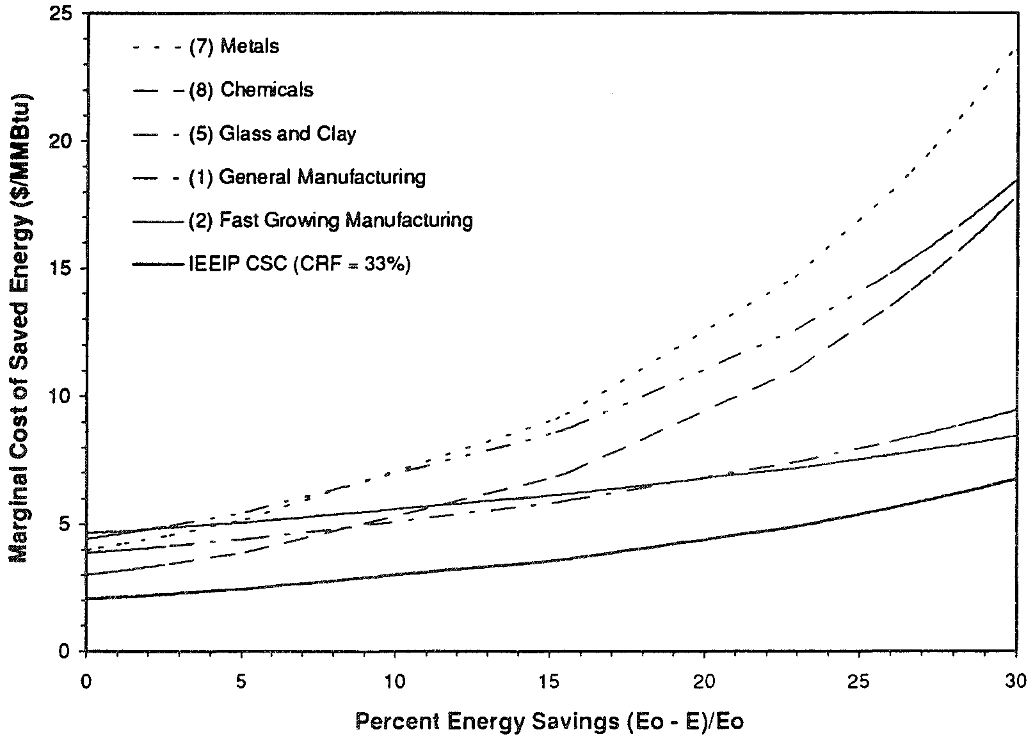


Figure 4. IEEI Program CSC from the Firm's Perspective (with and without DSM Incentives)

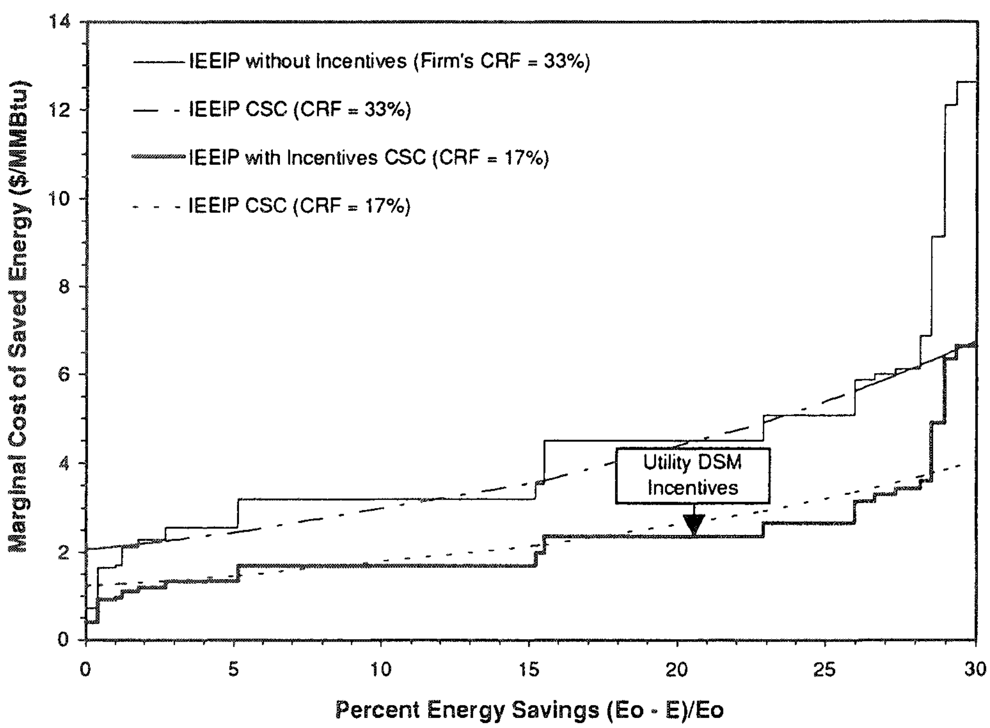


Table 6. LIEF Penetration Rates: Southern California Gas Company Core Industrial Sector

Sector Number	Description	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013
BASE CASE (NO DSM PROGRAMS)												
	All Sectors	-	0.25	1.00	2.00	2.00	1.00	1.00	0.50	0.50	0.50	0.00
3-YEAR DSM PROGRAMS (TY94GRC CALIBRATION)												
1	General Manufacturing	-	5.75	1.00	2.00	2.00	1.00	1.00	0.50	0.50	0.50	0.00
2	Fast Growing Manufacturing	-	5.75	1.00	2.00	2.00	1.00	1.00	0.50	0.50	0.50	0.00
5	Glass, Clay	-	5.75	1.00	2.00	2.00	1.00	1.00	0.50	0.50	0.50	0.00
7	Metals	-	5.75	1.00	2.00	2.00	1.00	1.00	0.50	0.50	0.50	0.00
8	Organic Chemicals	-	5.75	1.00	2.00	2.00	1.00	1.00	0.50	0.50	0.50	0.00
	All Other Sectors	-	0.25	1.00	2.00	2.00	1.00	1.00	0.50	0.50	0.50	0.00
20-YEAR DSM PROGRAMS												
1	General Manufacturing	-	5.75	2.60	2.00	2.00	1.00	1.00	1.00	1.00	1.00	0.85
2	Fast Growing Manufacturing	-	5.75	2.60	2.00	2.00	1.00	1.00	1.00	1.00	1.00	0.85
5	Glass, Clay	-	5.75	2.60	2.00	2.00	1.00	1.00	1.00	1.00	1.00	0.85
7	Metals	-	5.75	2.60	2.00	2.00	1.00	1.00	1.00	1.00	1.00	0.85
8	Organic Chemicals	-	5.75	2.60	2.00	2.00	1.00	1.00	1.00	1.00	1.00	0.85
	All Other Sectors	-	0.25	1.00	2.00	2.00	1.00	1.00	0.50	0.50	0.50	0.00

LIEF modeling results for the core industrial sectors and three scenarios are shown in **Figure 5** and **Table 7**. The calibration scenario shows savings of 0.2 TBtu in year 2013. The long-term 20-year DSM program scenario shows savings of 2.22 Trillion Btu in 2013. This represents 6.6 percent of the 33.36 TBtu base consumption in 2013. **Figure 6** and **Table 7** show the long-term DSM forecast for sectors 1, 2, 5, 7, and 8. The largest savings are in General Manufacturing (sector 1) with 1.45 TBtu (65%), followed by Fast Growing Manufacturing (sector 2) with 0.46 TBtu (20.6%). These two sectors account for 85.6% of total savings. The third largest savings are in Chemicals (sector 8) with 0.16 TBtu (7.2%). Metals (sector 7) is fourth with savings of 0.10 TBtu (4.5%), and Glass/Clay (sector 5) is fifth with savings of 0.06 TBtu (2.7%).

Table 7 shows cumulative conservation spending by all firms of $41.3 million over the 20-year period and cumulative natural gas savings of approximately 28 TBtu. This translates into $1.5/MMBtu saved, a good buy considering that the marginal cost of natural gas (excluding transmission costs) is about $2.10/MMBtu. To achieve this level of savings will require cumulative DSM incentives of approximately $17.9 million (assuming incentives are one-third of total spending plus thirty percent for administrative overhead). The Gas Company is currently spending about $2.2 million per year on industrial DSM programs.

CONCLUSION

The LIEF model results for Southern California Gas Company indicate potential natural gas savings from core industrial DSM programs of 2.2 trillion Btu per year in 2013. Compared to the non DSM base case scenario this represents a savings of about 7 percent. The cost to achieve these savings is about $41.3 million over the 20-year period and cumulative natural gas savings are 28 TBtu. The cost of conserved energy is $1.5/MMBtu saved. Almost 87 percent of the savings are from two sectors: General Manufacturing and Fast Growing Manufacturing.

LIEF can be used to forecast utility DSM savings provided there is sufficient data available on energy consumption and production growth rates by standard industrial classifications for industries within the utility service territory (preferably down to the four digit level). The advantage of using LIEF over other more complicated models is that LIEF is relatively easy to use and understand. Utility DSM planners can use LIEF to develop credible long-term forecasts that include the effects of utility DSM programs and other policies that affect long-term industrial demand.

Figure 5. Core Industrial Natural Gas Use (1993-2013)

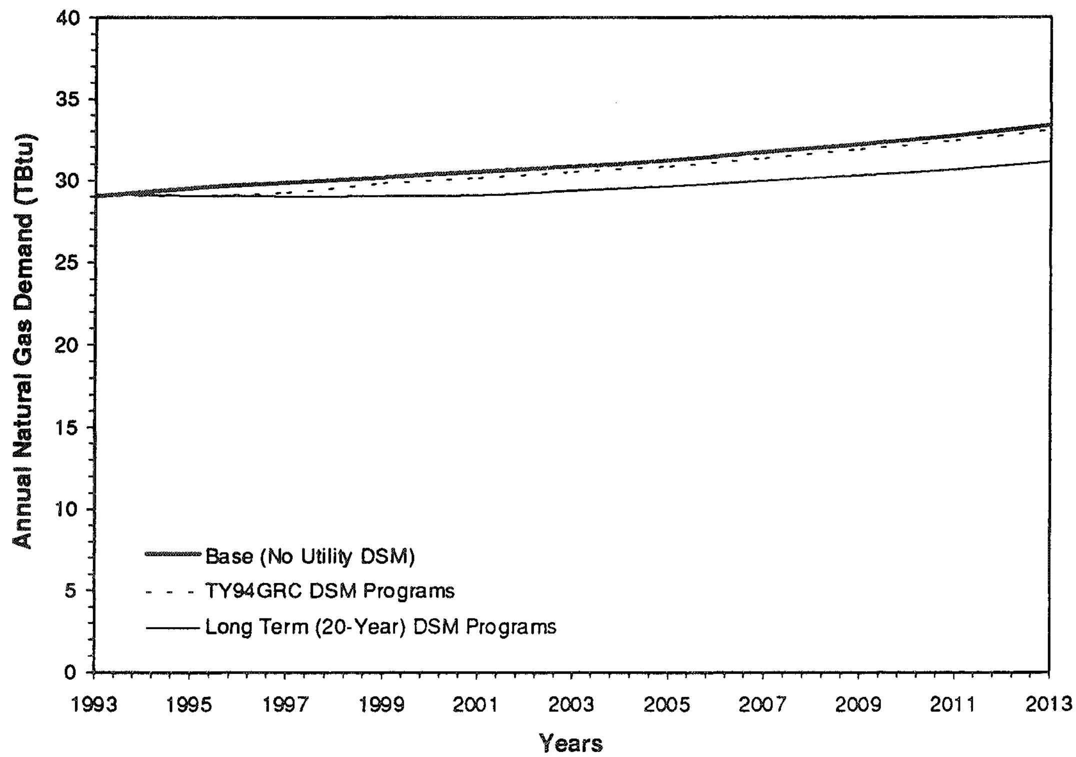


Figure 6. Forecast of Core Industrial DSM Savings by LIEF Sector

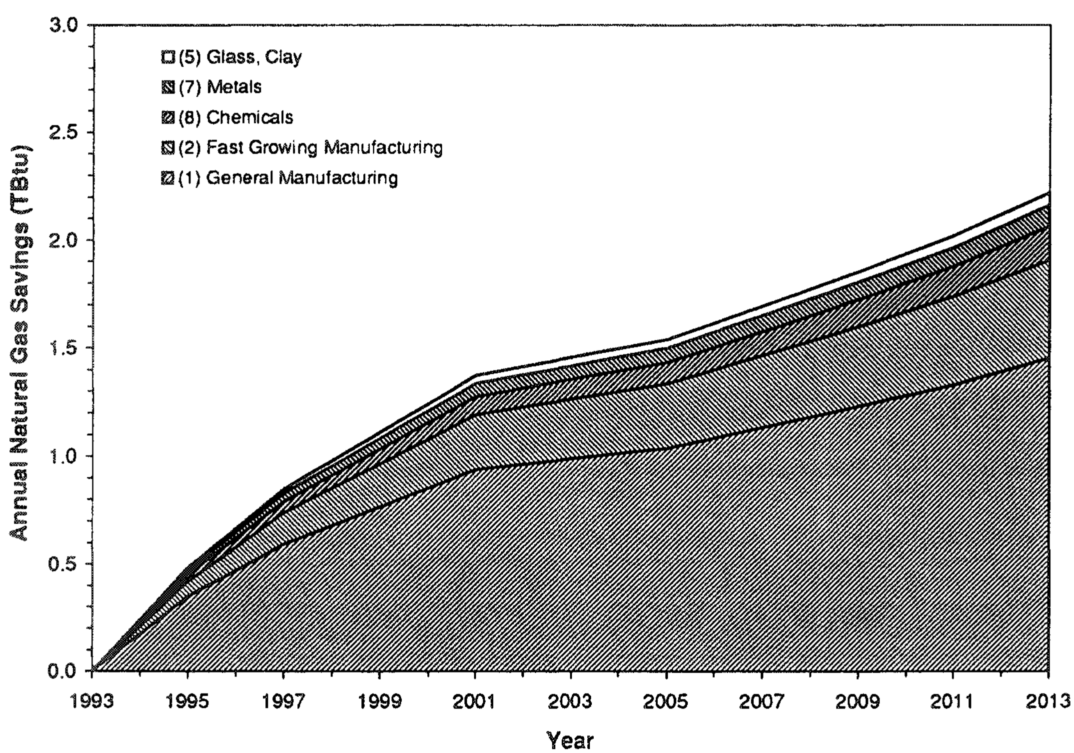


Table 7. LIEF Model Results (20-Year Forecast): Southern California Gas Company Core Industrial Sector

Sector Number	Description	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013
		Core Industrial DSM Savings (TBtu/Year)										
1	General Manufacturing	-	0.35	0.59	0.77	0.94	0.99	1.04	1.13	1.23	1.33	1.45
2	Fast Growing Manufacturing	-	0.07	0.14	0.20	0.25	0.27	0.30	0.33	0.37	0.41	0.46
3	Pulp and Paper	-	-	-	-	-	-	-	-	-	-	-
4	Petroleum Refining	-	-	-	-	-	-	-	-	-	-	-
5	Glass, Clay	-	0.01	0.02	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06
6	Cement	-	-	-	-	-	-	-	-	-	-	-
7	Metals	-	0.02	0.04	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.10
8	Organic Chemicals	-	0.03	0.05	0.07	0.08	0.09	0.10	0.11	0.12	0.14	0.16
9	Agriculture	-	-	-	-	-	-	-	-	-	-	-
10	Mining	-	-	-	-	-	-	-	-	-	-	-
11	Oil and Gas Extraction	-	-	-	-	-	-	-	-	-	-	-
12	Construction	-	-	-	-	-	-	-	-	-	-	-
ALL	Total Annual Savings	-	0.49	0.85	1.11	1.37	1.46	1.54	1.69	1.85	2.02	2.22
	Cumulative Savings (1994-2013)											28.09
	Base Consumption	29.01	29.53	29.85	30.17	30.49	30.83	31.22	31.70	32.19	32.71	33.36

Sector Number	Description	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013
			Core Industrial Spending on Conservation by Firms ($Million/Year)									
ALL	Annual Conservation Spending	-	5.99	5.89	5.16	5.49	2.93	3.13	3.16	3.38	3.57	2.59
	Cumulative Spending (1994-2013)											41.29

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ENDNOTES

1. The California Public Utilities Commission and the California Legislature encourage and in some cases require California utilities to invest in societally cost-effective DSM programs (see PU Code Section 701.1 [B]).

2. The Gas Company's industrial fuel substitution DSM programs provide economic incentives for customers to switch from a less source efficient electric technology to a more source efficient natural gas technology. These programs are similar to conservation programs that are modeled in LIEF using the conservation supply curve (CSC) methodology. LIEF only includes fuel substitution through the use of a parameter that is calibrated to historical data. The fuel substitution parameter in LIEF is not considered adequate for modeling fuel substitution measures included in The Gas Company's DSM programs. Therefore, fuel substitution measures are not included in this study.

3. Most of the discussion of the LIEF model is taken from Ross and Hwang 1992.

4. Total core sales in 1993 were approximately 372.6 TBtu. The core breakdown is 29.1 TBtu for industrial, 70.6 TBtu for Commercial, and 272.9 TBtu for Residential (California Gas and Electric Utilities 1993, and supplemental data from Ron Kent, report No. CB875, 01/28/94).

5. Discussion of the IEEI program conservation supply curve (IEEI CSC) is provided to demonstrate how such curves are developed. It is important to note that the IEEI CSC is not used in the LIEF model forecasts. The IEEI CSC only represents a subset of possible conservation measures and technologies that might be considered by firms. The IEEI program list is developed for a limited number of measures, each of which have high benefit-cost ratios. A more complete list of measures would have a higher y-intercept (lower *Gap0*) similar to the other curves. Since this paper was written Southern California Gas Company has revised their industrial DSM programs. Forecasts to reflect program changes are forthcoming.

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