**Industrial Operations and Maintenance
Demand-Side Management
Resource Development:
Literature and Data Review**

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Executive Summary

The Bonneville Power Administration (Bonneville) commissioned the Pacific Northwest Laboratory (PNL)^(a) to determine the industrial demand-side management (DSM) resource potential that may be achieved through operations and maintenance (O&M) practices in Pacific Northwest industries. This project has its background in the Resource Supply Expansion Program (RSEP).

The overall goal of this project is to determine, confirm, and develop the conservation resources that can be achieved from O&M practices in Pacific Northwest industries. This project is developmental in nature because its scope involves a sizable task whose path and direction is difficult to define in advance. To accomplish the goal, the project is divided into seven major tasks: 1) reviewing literature and data, 2) preparing project design and work plan, 3) establishing preaudit methodology, 4) performing plant audits, 5) implementing audit recommendations, 6) monitoring and documenting results, and 7) accomplishing technology transfer.

To assist in developing the specific goals and objectives of this ongoing project and its tasks, Bonneville and PNL assembled a Technical Advisory Committee (TAC) to act in both technical support and managerial steering roles. This report outlines the findings of the literature and data review (Task 1), which includes industrial electric end-use consumption estimates and industrial electric O&M energy conservation opportunities with potential energy savings.

The results of this study identify a significant electric resource potential available through O&M activities, both nationally and for the Pacific Northwest. The overall potential in the Pacific Northwest, identified in this study, ranges from a low of 4,903 million kWh/yr (559.7 aMW) from the Energy Analysis and Diagnostic Center (EADC) database analysis to a high of 7,414 million kWh/yr (846.3 aMW) from the general literature review.

The equipment category with the largest energy-savings potential is air compressors and compressed-air systems, followed closely by motors and motor drive systems. Table S.1 identifies the Pacific Northwest energy-savings potential by major end-use category derived from the EADC database. The specific O&M measure with the largest potential is repairing leaks in compressed-air lines. The ten industrial O&M energy measures with the largest energy-savings potential derived from the EADC database are identified in Table S.2. The industry with the largest energy-savings potential in the Pacific Northwest through O&M activities is Paper and Allied Products (standard industrial classification [SIC] code 26).

Based on the results of this study, the recommendation is to proceed with the additional project tasks to verify the O&M electric energy resource potential of air compressors and compressed-air systems, or the second alternative, motors and motor drive systems. Both of these categories offer significant energy-savings potential that can be readily achieved and maintained.

(a) Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

Table S.1. Summary of Pacific Northwest Industrial O&M Energy-Savings Potential by Major End-Use Category, 1990

<u>Major DIECO End-Use Category</u>	<u>PNW Potential (million kWh/yr)</u>	<u>PNW Potential (aMW)^(a)</u>
Air compressors and compressed-air systems	1,482.37	169.2
Motors and motor drive systems	1,129.63	129.0
Lighting	813.09	92.8
Heating, ventilating, and air conditioning systems	449.44	51.3
Equipment scheduling and control systems	431.35	49.2
Insulation	183.23	20.9
Ventilation systems	124.64	14.2
Refrigeration systems	78.47	9.0
Other miscellaneous opportunities	<u>211.20</u>	<u>24.1</u>
Total	4,903.42	559.8

(a) 1 aMW = 8.76 million kWh/yr

Table S.2. Top Ten Industrial O&M Energy-Saving Measures in the Pacific Northwest, 1990

<u>DIECO</u>	<u>DIECO Description</u>	<u>End-Use Equipment</u>	<u>PNW Potential (million kWh/yr)</u>	<u>PNW Potential (aMW)</u>
3231	Eliminate leaks in lines and valves carrying compressed-air or other gases	Air Compressors	1,040.46	118.8
5122	Improve lubrication practices for motor-driven equipment	Motors	613.34	70.0
5355	Use energy-efficient belts and other improved mechanisms	Motors	491.69	56.1
4112	Reduce operating time of equipment to the minimum required/install timers	Controls	278.81	31.8
6121	Install timers or motion sensors on little used lights or initiate schedule	Lighting	253.62	29.0
6111	Disconnect lighting fixtures, delamp, or use lower output lamps for min. light needed	Lighting	248.16	28.3
3221	Install compressor air intake in coolest location	Air Compressors	190.97	21.8
3211	Reduce the pressure of compressed air system to the minimum required	Air Compressors	175.13	20.0
5511	Insulate tanks, vessels, lines, and process equipment	Insulation	166.35	19.0
6244	Install or use timers or thermostats for space conditioning	HVAC	146.79	16.8

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1.0 Introduction

Industry in the Pacific Northwest consumes a significant percentage of the total regional electric load; however, industrial demand-side management (DSM) resource development activities in this sector are underdeveloped. One such opportunity for electricity resource development is through operations and maintenance (O&M) activities.

Despite the importance of industry in the Pacific Northwest, little information has been available on the DSM resource potential, particularly through O&M activities. To obtain this information, the Bonneville Power Administration (Bonneville) commissioned Pacific Northwest Laboratory (PNL) to study the DSM resource potential that may be achieved through O&M practices in Pacific Northwest industries. The information from this report will be used to identify one or more specific O&M activities or industries having significant opportunity for reducing electricity consumption for further evaluation in future tasks to this project.

The overall goal of this project is to determine, confirm, and develop the conservation resources that can be achieved from O&M practices in Pacific Northwest industries. This project is developmental in nature because its scope involves a sizable task whose path and direction is difficult to define in advance. To accomplish the project goal, the project is divided into seven major tasks: 1) reviewing literature and data, 2) preparing project design and work plan, 3) establishing preaudit methodology, 4) performing plant audits, 5) implementing audit recommendations, 6) monitoring and documenting results, and 7) accomplishing technology transfer. To assist in developing the specific goals and objectives of this ongoing project and its tasks, Bonneville and PNL assembled a Technical Advisory Committee (TAC) to act in both technical support and managerial steering roles.

The primary focus of this report is to summarize the major findings of the literature and data review (Task 1). Detailed analysis and use of all data gathered in the review are beyond the scope of this study. However, the reported findings in this analysis provide an extensive framework for identifying and estimating the electric resource potential available in the industrial manufacturing sector.

This report contains five sections. In Section 2.0, the major sources of industrial electricity end-use consumption estimates are identified and discussed. Section 3.0 presents the estimates of industrial electric O&M energy-savings potential from a review of published literature and the Energy Analysis and Diagnostic Center (EADC) database obtained from the U.S. Department of Energy (DOE). An impact analysis of O&M in the pulp and paper industry is presented in Section 4.0. Section 5.0 contains the conclusions of the analysis and presents recommendations for further study.

2.0 Industrial Electric End-Use Consumption Estimates

This section discusses and presents major sources of industrial energy consumption estimates by standard industrial classification (SIC) code, equipment end-use category, or process end-use category. This information functions as a baseline of industrial electric energy consumption, which is used in Section 3.0 to estimate the electric-energy resource potential through O&M measures.

2.1 Electrotechnology Reference Guide

The end-use categories provided in the *Electrotechnology Reference Guide* (ERG) is one of the most useful sources of end-use data available (Resource Dynamics Corporation 1992a). Although the data is based on professional estimates rather than metered data, ERG breaks out several relevant end-use categories for electric energy consumption. The ERG provides estimates for 1980, as well as 1990, making it the most up-to-date source identified. Table 2.1 presents the electric end-use data by industry SIC for the 1990 estimate from the ERG.

2.2 Electric Motors: Markets, Trends, and Applications

Electric Motors: Markets, Trends, and Applications (MOTORS) is a continuation of the same Electric Power Research Institute (EPRI) project as ERG (Resource Dynamics Corporation 1992b). Whereas ERG only separates motors into three categories, MOTORS further breaks down the energy consumption estimates as shown in Table 2.2. The MOTORS data estimates are for 1985. By combining the information from ERG and MOTORS, and prorating the data based on the 1990 estimate; the result is Table 2.3, which is illustrated in Figure 2.1. This estimate discounts any disparity in growth rates between the various end-use categories (i.e., assumes the growth rate of fans is the same as pumps and compressors).

2.3 Pacific Northwest Power Planning Council Industrial Energy Demand Model

This model provides estimates and projections of the industrial energy consumption for the Pacific Northwest and is presented in Table 2.4.^(a) A reasonable estimate for the Pacific Northwest is obtained by assuming the proportional breakdown of electric end-use from Table 2.3 and applying it to the regional estimates in Table 2.4. This estimate is presented in Table 2.5. Although this assumption overlooks regional variances, such as product and fuel mixes, it still provides the best breakdown of end-use categories. All estimates of end-use consumption and potential energy savings used in this study are based on Tables 2.4 and 2.5.

(a) Pacific Northwest Power Planning Council Industrial Energy Demand Model estimates were provided by Bonneville Power Administration.

2.4 Other Sources

Several other sources were reviewed for information concerning energy consumption and end-use breakdowns, some of which are briefly discussed in the following subsections. In general, these sources were not determined to be as applicable to the scope of this study as the previous sources discussed, but do deserve special mention.

2.4.1 Technical Assessment Guide

The *Technical Assessment Guide* (TAG) provides national baseline energy consumption for various manufacturing SIC codes based on 1985 estimates (Resource Dynamics Corporation 1988). The TAG report also describes various industry types, their processes, and technologies. In addition, it evaluates several new technologies. Although the majority of the information contained in the TAG report is not relevant to this study, the baseline information can be useful.

2.4.2 Industrial End-Use Planning Methodology

The *Industrial End-Use Planning Methodology* (INDEPTH) report identifies the percent breakdown of electricity consumption for 20 two-digit industry SIC codes and for 7 major end-use equipment types based on 1986 estimates (Battelle-Columbus Division 1986a). Like ERG and MOTORS, this data is also based on professional estimates rather than metered data. Applying the INDEPTH percentages to a national industrial electric consumption estimate can provide an estimate of electric end-use consumption.

There are certain faults with this information. In particular, the end-use categories are not very specific. The motors category, for example, covers a wide range of applications, including pumps, fans, air compressors, grinders, lathes, conveyors, and a variety of other drive systems. This differentiation in how a motor is applied is important in attributing O&M practices and therefore its energy reduction potential.

2.4.3 Energy-Use Patterns and Indicators

Energy-Use Patterns and Indicators, Volume 1: Summary provides national and regional energy consumption and trend estimates for major fuels (electricity, natural gas, petroleum, and coal) and markets (residential, commercial, and industrial) from 1960 to 1985 (Synergic Resources Corporation 1987). Although the end-use data provided is from INDEPTH, this report also includes electric consumption data for the agriculture, mining, and construction industries in addition to the manufacturing industry. While manufacturing accounted for 84.91% of the industrial electric energy consumption in 1980, agriculture, mining, and construction accounted for only 1.98%, 5.07%, and 8.05%, respectively. Beyond this source, very little other information was discovered concerning the agriculture, mining, and construction industries. *Energy-Use Patterns and Indicators* did provide agricultural electricity consumption by process end-use for livestock operations and crop operations from a 1978 U.S. Department of Agriculture (USDA) source.

2.4.4 Industrial Market Information System

The *Industrial Market Information System* (IMIS) database includes baseline estimates of national electric-energy consumption by four-digit SIC and 55 process end-use types (Battelle-Columbus Division 1986b). The process categories are identified in Table 2.6. The IMIS data are copyrighted and therefore not reproduced in this document; however, the data can be extracted from the IMIS software available through EPRI. While the process types are useful in some aspects, they do not correlate with the O&M measures identified later in Section 3.0. Industrial processes, while descriptive of the activity, usually consist of several equipment components, especially shared auxiliary equipment (such as air compressors). O&M activities, on the other hand, are usually associated with the equipment or its major components.

2.4.5 Noyes Data Corporation Series in Energy Conservation

Noyes Data Corporation published a series of handbooks on energy conservation, environmental control, and industrial processes for several industries from mid-1970 through mid-1980, only a few of which could be reviewed in time for this study. The Noyes handbooks are excellent sources for process descriptions, several of which include percentage breakdowns of energy end-use for both electricity and fossil fuels. The handbooks are also a good source for identifying applications of new technologies and research opportunities throughout industry.

2.4.6 Marketing Electricity to Industrial Consumers: A Study of Pacific Northwest Industries

The *Marketing Electricity to Industrial Customers* report provides percentage breakdowns of end-use energy consumption for five industries in the Pacific Northwest (SIC 20 - Food and Kindred Products, 24 - Lumber and Wood Products, 26 - Paper and Allied Products, 28 - Chemicals and Allied Products, and 33 - Primary Metals Industries) based on 1977 estimates (Northwest Economic Associates 1986). In addition to end-use estimates by two-digit SIC code, the report also provides end-use percentage estimates for a few four-digit SIC codes within each two-digit category. The estimates in this report were derived from previous research by Synergic Resources Corporation in 1981. Although the estimates are from 1977, it is still a good source for identifying major energy consumers within the industries covered. The information discovered through this source, however, is not considered further because it only covers 5 of the 20 two-digit SIC industries.

2.4.7 Bonneville Industrial Sector Conservation Supply Curve Database

Although the Bonneville Industrial Sector Conservation Supply Curve (ISCSC) database was not reviewed directly, the data was identified in another source (Baechler et al. 1992). The data, shown in Table 2.7, provides electric-load breakdowns for 8 two-digit industry SIC codes by 7 end-use categories. Although this is a good source of regional electric end-use for the Pacific Northwest, the 7 end-use categories were concluded not to be as beneficial as the previously described sources, ERG and MOTORS.

2.5 Conclusion

Because the sources presented in this section provide different end-use categories, it is difficult to merge the various sources together. For example, INDEPTH separates "chillers" from "motors" and "space heating" from "process heating;" while in Table 2.3, "compressors" includes chillers, refrigeration, air compressors, and other compressor equipment end-uses and "space heating" is combined with "lighting and other," with the exception of heat pumps, which is included in "process heating." Unfortunately, the end-use categories are not mutually exclusive and therefore cannot simply be merged into one large end-use breakdown. For this reason, the sources are presented individually for use with Section 3.0 findings as appropriate.

The ERG, MOTORS, and Pacific Northwest Power Planning Council Industrial Energy Demand Model derived resources, whose data are shown in Tables 2.3 and 2.5, provide, in the author's opinion, the most useful information within the manufacturing sector. It is unfortunate, however, that refrigeration compressors and air compressors are combined in the same end-use category; this will become relevant in Section 3.2.

The information derived from this section is used to calculate total energy consumption for a particular end-use category. Section 3.0 identifies the energy-savings potential of various O&M measures, which combined with the appropriate end-use energy consumption identified in this section, provides an estimate of the electric consumption savings potential.

Figure 2.1. Estimated National Manufacturing Electricity Consumption by End-Use Category and Sector, 1990 (million kWh)

Table 2.1. National Manufacturing End-Use Applications of Electricity by Category and Sector, 1990 (million kWh)

SIC	Motor Drives			Electrolytics			Process Heating			Lighting and Other	Total
	Pumps, Fans, Compressors	Material Processing	Material Handling	Separation/Synthesis	Reduction	Deposition/Removal	Melting and Holding	Heating	Drying and Curing		
20	21,700	13,600	14,000	0	0	0	500	200	0	7,300	57,300
21	400	700	600	0	0	0	0	0	0	400	2,100
22	4,700	10,500	8,200	0	0	0	0	0	700	4,300	28,400
23	800	2,300	1,300	0	0	0	0	0	300	600	5,600
24	3,400	5,500	7,000	0	0	0	0	0	300	4,700	20,900
25	800	2,700	1,100	0	0	0	0	0	300	1,100	6,000
26	37,900	32,700	32,700	0	0	0	0	0	1,500	6,000	110,800
27	3,400	4,900	4,400	0	0	0	0	500	800	4,300	18,300
28	97,900	13,100	19,600	33,300	0	0	0	800	0	6,100	171,800
29	31,900	4,300	6,400	0	0	0	0	700	0	1,600	44,800
30	8,000	8,100	9,700	0	0	0	0	3,800	800	5,600	36,100
31	100	300	100	0	0	0	0	0	0	400	900
32	4,800	10,100	8,400	0	0	0	4,300	2,800	0	2,100	32,300
33	12,200	30,300	16,300	0	58,200	4,000	21,500	1,600	0	4,800	152,000
34	2,800	5,600	3,700	0	3,900	0	0	13,800	200	2,500	32,300
35	3,300	7,300	7,600	0	200	0	0	12,600	0	4,300	35,500
36	6,400	10,400	4,000	0	0	0	0	4,700	100	7,200	32,800
37	5,600	5,800	4,600	0	200	0	100	14,700	1,000	4,800	36,700
38	1,800	6,100	3,100	0	0	0	0	1,800	0	2,100	14,700
39	600	1,900	1,300	0	0	0	0	400	0	900	5,100
	248,300	178,300	156,100	33,300	63,500	4,000	26,400	58,200	5,900	71,600	843,500

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Table 2.2. National Manufacturing Sector Motor Drive Electricity Use, 1985 (million kWh)

SIC	Pumps	Fans	Compressors	Crushing	Cutting	Mixing	Forming	Material Handling	Total
20	8,100	3,800	5,300	2,500	2,700	4,300	1,300	14,000	42,000
21	100	100	0	0	300	100	100	600	1,300
22	1,700	1,200	1,300	800	5,100	2,100	1,600	8,200	22,000
23	300	300	200	100	1,700	400	100	1,300	4,400
24	800	2,000	800	500	4,100	500	400	7,000	15,800
25	100	300	200	300	1,400	100	200	1,100	3,700
26	18,500	5,000	4,500	4,800	8,900	8,900	1,600	32,700	84,900
27	700	800	700	200	1,800	1,200	300	4,400	9,900
28	33,000	8,400	24,900	1,800	400	5,400	1,200	19,800	85,800
29	18,800	6,300	3,700	1,200	100	2,300	200	6,400	38,800
30	3,700	1,800	1,400	600	1,800	2,700	2,100	9,700	23,800
31	100	100	0	0	200	0	0	100	500
32	2,100	1,700	1,800	8,600	1,800	1,600	1,800	8,400	25,800
33	3,300	4,400	1,500	7,300	3,100	3,400	9,200	18,300	50,500
34	500	1,000	1,000	800	1,500	500	2,500	3,700	11,800
35	800	1,200	1,000	1,100	2,100	500	2,700	7,800	17,000
36	2,000	3,200	2,800	2,000	3,800	1,100	6,100	4,000	25,200
37	2,000	2,800	2,800	1,100	3,000	700	3,200	4,800	20,200
38	200	300	400	400	1,000	500	1,100	3,100	7,000
39	100	100	100	200	300	200	500	1,300	2,800
	98,700	45,800	54,100	32,500	44,800	38,500	38,200	156,100	502,700

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Table 2.3. Estimated National Manufacturing Electricity Consumption by End-Use Category and Sector, 1990 (million kWh)

SIC	Industry	Motor Drives							Material Handling
		Pumps	Fans	Compressors	Crushing	Cutting	Mixing	Forming	
20	Food and Kindred Products	10,219	4,794	6,687	3,148	3,400	5,415	1,637	14,000
21	Tobacco	200	200	0	0	420	140	140	600
22	Textile Mill Products	1,902	1,343	1,455	875	5,578	2,297	1,750	8,200
23	Apparel and Other Textile Products	300	300	200	100	1,700	400	100	1,300
24	Lumber and Wood Products	800	2,000	800	500	4,100	500	400	7,000
25	Furniture and Fixtures	133	400	267	405	1,890	135	270	1,100
26	Paper and Allied Products	25,041	6,768	6,091	6,486	12,026	12,026	2,162	32,700
27	Printing and Publishing	1,082	1,236	1,082	297	2,376	1,782	445	4,400
28	Chemicals and Allied Products	48,004	13,874	36,222	2,797	589	7,948	1,788	19,800
29	Petroleum and Coal Products	20,746	7,027	4,127	1,356	113	2,603	226	6,400
30	Rubber and Plastics Products	4,290	2,087	1,623	694	1,851	3,124	2,430	9,700
31	Leather and Leather Products	50	50	0	0	300	0	0	100
32	Stone, Clay, Glass, and Concrete Products	1,867	1,511	1,422	5,648	1,541	1,399	1,541	8,400
33	Primary Metal Industries	4,376	5,635	1,899	9,617	4,084	4,479	12,120	18,300
34	Fabricated Metal Products	520	1,040	1,040	933	1,556	519	2,593	3,700
35	Machinery, except Electrical	880	1,320	1,100	1,255	2,395	570	3,080	7,600
36	Electric and Electronic Equipment	1,580	2,528	2,291	1,568	3,066	873	4,843	4,000
37	Transportation Equipment	1,474	2,063	2,063	811	2,213	516	2,360	4,600
38	Instruments and Related Products	400	600	800	813	2,033	1,017	2,237	3,100
39	Miscellaneous Manufacturing Industries	200	200	200	317	475	317	792	1,300
Total		124,065	54,977	69,258	37,643	51,736	48,030	40,891	156,100

SIC	Industry	Electrolytics			Process Heating			Lighting and Other	Total
		Separation/Synthesis	Reduction	Deposition/Removal	Melting and Holding	Heating	Drying and Curing		
20	Food and Kindred Products	0	0	0	500	200	0	7,300	57,300
21	Tobacco	0	0	0	0	0	0	400	2,100
22	Textile Mill Products	0	0	0	0	0	700	4,300	28,400
23	Apparel and Other Textile Products	0	0	0	0	0	300	900	5,600
24	Lumber and Wood Products	0	0	0	0	0	300	4,700	20,900
25	Furniture and Fixtures	0	0	0	0	0	300	1,100	8,000
26	Paper and Allied Products	0	0	0	0	0	1,500	6,000	110,800
27	Printing and Publishing	0	0	0	0	500	800	4,300	18,300
28	Chemicals and Allied Products	33,300	0	0	0	800	0	6,100	170,800
29	Petroleum and Coal Products	0	0	0	0	700	0	1,600	44,900
30	Rubber and Plastics Products	0	0	0	0	3,800	600	5,900	36,100
31	Leather and Leather Products	0	0	0	0	0	0	400	900
32	Stone, Clay, Glass, and Concrete Products	0	0	0	4,300	2,800	0	2,100	32,300
33	Primary Metal Industries	0	59,200	4,000	21,500	1,800	0	4,900	152,000
34	Fabricated Metal Products	0	3,900	0	0	13,800	200	2,500	32,300
35	Machinery, except Electrical	0	200	0	0	12,800	0	4,300	35,500
36	Electric and Electronic Equipment	0	0	0	0	4,700	100	7,200	32,800
37	Transportation Equipment	0	200	0	100	14,700	1,000	4,800	36,700
38	Instruments and Related Products	0	0	0	0	1,800	0	2,100	14,700
39	Miscellaneous Manufacturing Industries	0	0	0	0	400	0	900	5,100
Total		33,300	63,500	4,000	26,400	58,200	5,800	71,600	643,500

Table 2.4. Pacific Northwest Power Planning Council Industrial Energy Demand Regional Total for All Industries by Two-Digit SIC, 1990 (aMW)

<u>SIC</u>	<u>Industry</u>	<u>1990 (aMW)</u>
20	Food and Kindred Products	296.68
21	Tobacco	~0.00
22	Textile Mill Products	5.73
23	Apparel and Other Textile Products	4.02
24	Lumber and Wood Products	528.37
25	Furniture and Fixtures	4.83
26	Paper and Allied Products	1,495.15
27	Printing and Publishing	50.13
28	Chemicals and Allied Products	770.80
29	Petroleum and Coal Products	106.87
30	Rubber and Plastics Products	91.20
31	Leather and Leather Products	~0.00
32	Stone, Clay, Glass, and Concrete Products	134.37
33	Primary Metal Industries	2,831.17
34	Fabricated Metal Products	61.81
35	Machinery, except Electrical	133.36
36	Electric and Electronic Equipment	60.60
37	Transportation Equipment	168.68
38	Instruments and Related Products	12.37
39	Miscellaneous Manufacturing Industries	14.72
	Residual	35.55
	Total	6,806.41

Table 2.5. Estimated Manufacturing Electricity Consumption by End-Use Category and Sector for the Pacific Northwest, 1990 (million kWh)

SIC	Industry	Motor Drives							Material Handling
		Pumps	Fans	Compressors	Crushing	Cutting	Mixing	Forming	
20	Food and Kindred Products	483.5	217.4	303.3	142.8	154.2	245.8	74.2	635.0
21	Tobacco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	Textile Mill Products	3.4	2.4	2.8	1.5	9.9	4.1	3.1	14.5
23	Apparel and Other Textile Products	1.9	1.9	1.3	0.6	10.7	2.5	0.6	8.2
24	Lumber and Wood Products	177.2	442.9	132.9	110.7	908.0	110.7	88.6	1,550.2
25	Furniture and Fixtures	0.9	2.8	1.9	2.9	13.3	1.0	1.9	7.8
26	Paper and Allied Products	2,960.1	800.0	720.0	788.7	1,421.6	1,421.6	255.8	3,885.4
27	Printing and Publishing	28.0	29.7	28.0	7.1	57.0	42.8	10.7	105.6
28	Chemicals and Allied Products	1,897.8	540.8	1,431.9	110.8	23.3	314.2	89.8	774.8
29	Petroleum and Coal Products	432.8	148.5	86.0	28.3	2.4	54.3	4.7	133.4
30	Rubber and Plastics Products	94.9	48.2	35.9	15.4	41.0	69.1	53.8	214.7
31	Leather and Leather Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	Stone, Clay, Glass, and Concrete Product	68.0	55.1	51.8	205.9	56.1	49.9	56.1	306.1
33	Primary Metal Industries	714.0	952.0	324.8	1,599.1	698.4	730.8	1,977.8	2,985.9
34	Fabricated Metal Products	8.7	17.4	17.4	15.8	26.1	8.7	43.5	62.0
35	Machinery, except Electrical	29.0	43.4	36.2	41.3	78.8	18.8	101.3	250.1
36	Electric and Electronic Equipment	25.6	40.9	37.1	25.7	50.1	14.1	78.4	64.7
37	Transportation Equipment	59.3	83.1	83.1	32.7	89.1	20.8	95.0	185.2
38	Instruments and Related Products	2.9	4.4	5.9	6.0	15.0	7.5	18.5	22.9
39	Miscellaneous Manufacturing Industries	5.1	5.1	5.1	8.0	12.0	8.0	20.0	32.9
Total		6,970.8	3,431.8	3,302.9	3,090.9	3,634.9	3,124.4	2,951.4	11,219.4

SIC	Industry	Electrolytics			Process Heating			Lighting and Other	Total
		Separation/Synthesis	Reduction	Deposition/Removal	Melting and Holding	Heating	Drying and Curing		
20	Food and Kindred Products	0.0	0.0	0.0	22.7	9.1	0.0	331.1	2,598.9
21	Tobacco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	Textile Mill Products	0.0	0.0	0.0	0.0	0.0	1.2	7.6	50.2
23	Apparel and Other Textile Products	0.0	0.0	0.0	0.0	0.0	1.9	5.7	35.2
24	Lumber and Wood Products	0.0	0.0	0.0	0.0	0.0	66.4	1,040.9	4,628.5
25	Furniture and Fixtures	0.0	0.0	0.0	0.0	0.0	2.1	7.8	42.3
26	Paper and Allied Products	0.0	0.0	0.0	0.0	0.0	177.3	709.3	13,097.5
27	Printing and Publishing	0.0	0.0	0.0	0.0	12.0	19.2	103.2	439.1
28	Chemicals and Allied Products	1,318.4	0.0	0.0	0.0	31.8	0.0	241.2	6,752.2
29	Petroleum and Coal Products	0.0	0.0	0.0	0.0	14.6	0.0	33.4	936.2
30	Rubber and Plastics Products	0.0	0.0	0.0	0.0	84.1	13.3	130.6	798.9
31	Leather and Leather Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	Stone, Clay, Glass, and Concrete Product	0.0	0.0	0.0	156.7	94.7	0.0	78.5	1,177.1
33	Primary Metal Industries	0.0	9,659.4	652.7	3,506.0	261.1	0.0	799.5	24,801.0
34	Fabricated Metal Products	0.0	65.4	0.0	0.0	231.3	3.4	41.9	541.5
35	Machinery, except Electrical	0.0	6.8	0.0	0.0	421.2	0.0	141.5	1,188.2
36	Electric and Electronic Equipment	0.0	0.0	0.0	0.0	76.1	1.6	118.5	530.9
37	Transportation Equipment	0.0	8.1	0.0	4.0	591.9	40.3	185.2	36,700.0
38	Instruments and Related Products	0.0	0.0	0.0	0.0	11.8	0.0	15.5	14,700.0
39	Miscellaneous Manufacturing Industries	0.0	0.0	0.0	0.0	10.1	0.0	22.8	128.9
Total		1,318.4	9,739.4	652.7	3,691.4	1,849.8	326.7	4,006.9	59,312.7

Table 2.6. Process Description Code for IMIS Database

Process Code	Process Description
1	CUTTING, SAWING, SLITTING
2	TURNING
3	GRINDING
4	GEAR CUTTING
5	ROLLING
6	EXTRUSION
7	FORGING, UPSETTING
8	DRAWING
9	FINISH ROLLING
10	ROTARY FORMING, SWAGING
11	STAMPING
12	DEEP DRAWING
13	EMBOSSING, COINING
14	FORMING
15	POWDER METALLURGY PROCESSES
16	CASTING, MELTING
17	WELDING, JOINING
18	CLEANING, PRETREATMENT
19	PAINTING
20	COATING, FINISHING
21	PLATING
22	METAL SPRAYING
23	DRYING, BAKING
24	HEAT TREATING
25	ASSEMBLY
26	PREHEATING
27	MATERIALS HANDLING
28	SIZE REDUCTION
29	AGGLOMERATION
30	HEATING
31	MELTING
32	ANNEALING
33	COOLING
34	WATER REMOVAL
35	SEPARATIONS - SOLID/SOLID
36	SEPARATIONS - SOLID/LIQUID
37	SEPARATIONS - LIQUID/LIQUID
38	SEPARATIONS - LIQUID/GAS
39	SEPARATIONS - GAS/GAS
40	SYNTHESIS/CHEMICAL REACTIONS
41	FABRICATION
42	SPACE CONDITIONING/MISC
43	LIGHTING
44	MOLDING
45	SEPARATIONS - SOLID/GAS
46	ELECTRONICS, ELECTROSTATICS
47	PHOTOCHEMICAL PROCESSING
48	SMELTING
49	ELECTROLYSIS
50	MIXING, COMPOUNDING
51	CURING
52	SLASHING, BEAMING
53	WASHING, DESIZING, SCOUR
54	DYEING
55	WATER REMOVAL - BULK

Table 2.7. Pacific Northwest Electric Load-Sharedowns by Industry, Bonneville ISCSC Database, 1988 (%)

<u>SIC</u>	<u>Industry</u>	<u>Motors</u>	<u>Heating</u>	<u>Lighting</u>	<u>A/C</u>	<u>Compression</u>	<u>Refrigeration</u>	<u>Electrochemical</u>	<u>Total</u>
20	Food and Kindred Products	88	0	8	5	0	20	0	89
24	Lumber and Wood Products	82	0	4	2	2	0	0	100
26	Paper and Allied Products	84	0	5	1	0	0	0	100
28	Chemicals and Allied Products	25	54	6	2	4	1	7	99
29	Petroleum and Related Industries	56	36	6	2	0	1	0	101
32	Stone, Clay, and Glass Products	77	11	8	4	0	0	0	100
33	Primary Metals Industries	18	5	5	1	0	0	70	99
37	Transportation Equipment	70	7	16	5	2	0	0	100

3.0 Industrial Electric O&M Energy Conservation Opportunities and Potential Energy Savings

This section presents the findings of the literature and data search into potential energy savings through O&M energy measures. To accomplish this and to establish a commonality with the reader, a working definition for O&M is presented. Estimates of energy savings and results of case studies, which were identified in the research, are then presented. This information is then correlated to the industrial energy consumption identified in Section 2.0 to establish an estimate of overall energy-saving potential for the various O&M energy measures in the United States and the Pacific Northwest.

3.1 Defining O&M

Before reviewing literature and data sources for energy-savings potential, it is first important to define what is implied through the term O&M. There are several different categories of maintenance. Fuchs (1993) defines six different categories of maintenance, including preventive maintenance (and predictive), unscheduled repairs, emergency repairs, scheduled maintenance, and routine maintenance activities. In addition, Fuchs defines four categories of non-maintenance, including construction, equipment installation, equipment relocation, and equipment modification. Although these definitions may cover maintenance, none of these terms considers operations.

To assist in developing a working definition for O&M, PNL utilized the resources of the TAC. After much discussion, the following multifaceted definition resulted:

- an activity that is financed as an expense rather than capital
- a low-cost item that can be installed or performed by the O&M staff, although it may be contracted; an activity or item that is considered a routine capability
- an item or activity that has a simple payback of less than one year
- any item or activity that will bring the equipment back to its original design and specification; e.g., repair
- a repetitive activity; e.g., preventive and predictive maintenance
- any activity affecting the operation of the equipment, e.g., control settings, set points, schedules, and procedures

The above definition still brings much potential for debate, even among the authors and members of the TAC. Not everybody's definition of O&M is the same and the reader may consider some measures in the following discussion to be capital items. The reader should note, however, that each energy measure is identified separately and in enough detail that the reader may remove select energy measures and use the information accordingly.

3.2 Findings of Industrial Electric O&M Potential Energy Savings

Numerous publications were reviewed to identify industrial energy-savings potential through O&M activities with only moderate success. Although there are a number of publications that contain information such as energy conservation checklists, O&M activities and O&M energy impacts, there is very little quantifiable data useful in compiling a picture by industry or end-use. The general problem is that the literature is fragmented and specific information regarding energy savings impact of O&M activities is very limited. The information that is identified is based mainly on small case studies with limited generalized energy-savings impact of O&M measures, or it is over-generalized expert opinions, not measured data.

The information obtained is summarized in Table 3.1. This information identifies several O&M measures and an estimated percent energy-savings potential for each measure. In order to estimate overall energy-savings potential, it is necessary to associate a single end-use category with each O&M measure. Engineering judgement is used to determine the "best fit" of end-use category to the O&M measure. From this information and the associated end-use category from Section 2.0, estimates of the national and Pacific Northwest regional electric energy-savings potential are calculated. These estimates are also shown in Table 3.1.

Table 3.1 lists potential energy savings derived from a variety of different sources, ranging from small case studies to expert opinions. There is a significant amount of overlap in categories and duplication of energy conservation measures, often with different reported savings estimates. A second limitation to these findings is uncertainty in determination of the end-use category utilized in the calculations. Because the end-use category chosen as the "best fit" is not always a perfect fit, as referred to in Section 2.5, there is an inherent source of error in the estimates of total energy savings. These are the two principal limitations to Table 3.1. It is significant that the electric energy use categories listed in Table 3.1 are almost all motor related. As shown in Table 2.5 and 2.3, motors account for 64% of the industrial electric energy consumption in the Pacific Northwest, although on a national level motors account for 72% of manufacturing electric energy consumption. This difference is due predominantly to the heavy use of electrolytic separation in the aluminum industry in the Pacific Northwest.

Duplication in Table 3.1 exists in the categories of drive systems, lubricants, and compressor controls. For example, of the 32 energy conservation measures listed, five involve improved lubricants for motors alone. The range of savings estimated for this conservation measure varied widely with the different references, covering a range from 0.63% to 11.5% of the motor's electric energy consumption. The wide variation makes an accurate savings estimate difficult for this particular O&M measure. Also implicit in Table 3.1 is the assumption that all motors can use improved lubricants. It is unknown to what extent these improved lubricants have already penetrated the market.

Note also that three measures are aimed at improving the efficiency of belt drives. Lovins (et al. 1989) estimates that 22% of industrial motor shaftpower is transmitted through belt drives. V-belt drive efficiency typically ranges from 90 to 96%. Lower figures result from belt slippage and from energy dissipated in belt flexing, both of these inefficiencies increase with smaller pulley sizes. Industry estimates suggest that 30 to 60% of these belt drives are not well maintained. In general, this refers to improper belt tension. Savings from switching to energy efficient v-belts (referred to as

cogged v-belts) or synchronous belts should be small over a well maintained drive and large over a poorly maintained drive. The use of cogged or synchronous belts is of course mutually exclusive. One laboratory study comparing synchronous belts with well maintained v-belts drives reports a 5.6% savings using synchronous belts in small, 3 in. pulleys and a 2.0% savings using 8 in. pulleys (Lovins et. al 1989). The same report suggests that the savings over cogged belts was 3.6% and 0.5% respectively. Table 3.1 applies the average of these to all pulleys and to all belt drive systems. In actual practice, the significant savings differences due to the pulley size might make synchronous belts a worthwhile investment only in certain instances, although the savings in maintenance may also make them attractive.

Lead/lag controllers are control devices used in pneumatic or fluid systems where more than one compressor or pump is required and where the air or fluid flow varies. The controls are used to cycle certain compressors (or pumps) in the system on or off in order to keep the working compressors (or pumps) in the system operating at an optimal efficiency and required flow. Thus, the savings potential listed for lead/lag controllers on compressors and pumps is only applicable to systems with multiple compressors or pumps. The fraction of systems that meet this criteria is unknown, however it is not all of the compressor or pump systems.

Fast controllers are lead/lag controllers which also match pressure set points to variable loads and reduce compressor surges. The reported savings potential for fast controllers and lead/lag controllers suggests that much of the savings is implementing a lead/lag effect, and thus only applicable to multiple compressor systems. Because the cost of these controllers are not very dependent on compressor size, they are particularly attractive in large compressor systems.

Repair of leaks in compressed air systems is a very common O&M issue with good payback. It is labor intensive however, and to keep up with the system it is important that leaks be checked on a regular basis. The savings associated with this measure have been applied to the compressor end-use category taken from Table 2.3 and Table 2.5. As noted in Section 2.5, these tables do not separate air compressors from refrigerant compressors therefore, the savings estimates from this specific example are somewhat overstated. The savings reported for general air compressor O&M is the result of air compressor audits at four North Carolina industrial plants (Singh et al. 1990). The study estimated that the average savings for manufacturing plants in that state would be 12.6% of compressor energy.

Most motor O&M measures involve some type of tune-up of the plant electrical system or better scheduling of the motor use to the application. Controlling phase imbalance or plant supply voltage allows maintenance personnel to consistently improve motor performance throughout the plant. It is important that motors be properly sized for the load and that proper voltage be applied. If a plant uses predominantly dual voltage motors, it may be hard to correct the plants line voltage to achieve an optimum performance. Phase imbalance primarily results from large loads on only one phase of the plants electrical network. Correction requires redistributing these loads across each electrical phase to balance power draw.

The application of the individual electric tune-up measures listed by Lovins suggest a 5.5% savings, however this is from studies of individual motors. A second source (Nadel et al. 1991) reports a higher savings of 8%. Correcting voltage imbalance between phases on a polyphase motor can significantly improve the motors efficiency. A report by Argonne National Laboratory (1980) suggests that approximately 93% of U.S. motor energy is consumed by polyphase motors 5 H.P. and greater.

Improved motor use and scheduling, operational changes and improved maintenance practices were lumped together by Smith (1978) as having a total estimated savings of between 2 and 5% (average 3.5%). It should be noted that this is lower than the savings predicted by Lovins and Nadel just for electrical tune up measures.

The measures listed can be broken down into those that directly affect the motors such as voltage reduction, those that directly affect the drive system such as using synchronous belts, those that affect the end-use such as compressor controls and cleaning of heating, ventilating, and air conditioning (HVAC) coils, and those that are "group" measures, reflecting the result of an O&M program. When broken down in this fashion, the results of measures in the first three categories have a interactive, not an additive effect.

For example, a 20% savings in an air compressor's energy consumption due to the installation of a fast controller results in the compressor system using 80% of it's original consumption. If cogged v-belts are then used on this compressor and the savings is 2.7%, it is applied to the new energy consumption (80% of original) so that the compressor uses 77.8% of it's original load ($80\% \times [100\% - 2.7\%]$). Applying correct voltage to the above motor might result in an additional 3.3% savings so that the compressor would finally use 75.2% ($77.8\% \times [100\% - 3.3\%]$) of it's original energy consumption, not the 74% predicted by adding the savings independently ($100\% - [20\% + 2.7\% + 3.3\%]$). Therefore savings estimates from interactive measures should not simply be totaled, although in some cases this may be done to arrive at order-of-magnitude estimates for a plant-wide, regional, or national estimate of potential energy savings.

It is necessary to break the energy conservation measures into these categories to understand their cumulative effect and calculate the actual energy savings possible through an O&M program. With the "grouped" categories, such as an overall energy management program, experimental results are typically compiled from individual case studies and without knowing the individual measures applied in each study, they are difficult to use as a reference for potential energy savings in other applications. They do have the advantage that if they are representative of an industry, the measured energy savings already take into account the cumulative effects illustrated above.

Of the individual measures listed, the obvious standouts are repair of leaks in compressed-air systems, installation of lead/lag controls on compressors in multiple compressor systems, and general electrical system tune up for motors. The fact that two of these focus on compressed-air systems illustrates the importance of compressed-air management programs. There are still important issues to be resolved on the savings potential because of the use of improved lubricants in motor and motor drive applications, although it is possible that this is also a significant and low cost measure. Lovins (et al. 1989) points out that it can even have a negative cost because the new lubricants may have a significantly longer life than traditional lubricants.

Complete O&M programs can save a significant amount of the total energy consumption in a facility. The reported savings for school buildings suggests that energy savings can be upwards of 30% (Lewis 1991). Although application of this percentage to industry, where more of the energy use is in heavy mechanical equipment, may be questionable, it does suggest what is possible. EPRI (Smith 1978) suggests that for mechanical equipment of all types a savings of 10 to 15% can be expected from O&M procedures alone. Because most mechanical equipment in industry is driven by motors, this represents a savings potential of 4,715 million kWh/yr in the Pacific Northwest and 72,600 million kWh/yr in the United States. Because proper O&M also results in longer equipment

life, better product output, and improved quality, energy savings can often be achieved at a zero or negative total cost to industry. Accounting for non-energy benefits of O&M is important to the overall economic evaluation of this potential resource.

3.3 Energy Analysis and Diagnostic Center Database

The Energy Analysis and Diagnostic Center (EADC) program has offered no-cost energy conservation audits to industrial plants since 1976. A database of detailed plant and audit information has been maintained since 1980. The database currently resides at Rutgers University (McHugh and Winn 1992). PNL acquired a copy of the database in support of this analysis.

3.3.1 EADC Background

EADC is a program funded through DOE. The EADC uses graduate and undergraduate engineering students under the direction of university faculty members to perform energy surveys of small- to medium-sized manufacturing plants. These audits are offered at no charge to the clients. The program began in 1976 with 4 universities acting as centers. The program has since expanded to 22 universities, with plans to expand to 40 by 1998 (Glasser 1992).

To be accepted as an EADC client, manufacturing plants must meet certain criteria, including: 1) annual energy bills less than \$1.75 million, 2) annual gross sales less than \$75 million at the plant site, 3) between 50 to 500 employees at the plant site, 4) no on-site energy manager, 5) located within 150 miles of an EADC, and 6) a SIC code between 20 and 39 (Glasser 1992).

These audits generally consist of one- to two-day site visits by an EADC team. The EADC team usually consists of a supervising faculty member and 2 to 4 engineering students. After the on-site visit, the EADC generates a technical report for the client. The report contains a detailed plant and manufacturing process description, a list identifying the major energy consuming equipment, a historical survey of plant energy consumption, and a detailed analysis of cost effective energy conservation opportunities (ECOs). Approximately one year after the report is complete, the client is contacted to participate in an implementation survey. This information is then added to the EADC database.

3.3.2 Database Description

The database contains information from over 2,400 audits conducted from 1980 to 1990 from 16 EADCs and includes data on over 15,600 specific energy conservation recommendations. The energy conservation measures in the database are identified by codes from the Directory of Industrial Energy Conservation Opportunities (DIECO).^(a) PNL, with assistance from the TAC, classified 80 DIECOs as electric O&M energy-saving measures; these are listed in Table 3.2. The EADC database contains over 5,500 records (over 35%) pertaining to electric O&M measures.

(a) DIECO is a listing of standard industrial efficiency measures developed by the University City Science Center in Philadelphia.

3.3.3 Advantages and Limitations of the Database

The EADC database has several advantages and limitations as it pertains to this analysis. The most important advantage is that the EADC database is reported to be the only database consisting of ECOs for a full range of DSM measures (including fuel switching) based on actual energy audits. The database also contains a large sample from several geographic locations and includes all but one industry group (SIC 21 - Tobacco Manufacturers). The database also contains considerable information on the facility, its baseline, fuel types, as well as the individual ECO information, including implementation data.

There are, however, some limitations to the database. The most important of these is the client base itself, small- to medium-sized plants. Application of the EADC data to large facilities, as is done in this analysis, will likely introduce some error. Larger facilities, while fewer in number, consume a majority of energy within the manufacturing sector. Larger facilities are sometimes assumed to be more efficient and have improved control over their energy consumption. If this is the case, application of the EADC database to larger facilities may tend to over estimate the potential energy savings. This hypothesis, however, has not been tested.

Another limitation of the database is that while the database includes data for several fuels, including electricity, it does not contain data on electric demand. In addition, although the database is based on actual energy audits, energy savings are based on engineering estimates, not metered data. Finally, the baseline energy consumption in the database is for the entire plant, not for end-use.

3.3.4 Database Analysis

The results of the database analysis are shown in Tables 3.3 through 3.10. Table 3.3 identifies the number of plant audits performed by the 16 EADCs included in the database by industry SIC (2-digit). This information is illustrated in Figure 3.1. The information by four-digit SIC is available in the database, but would be too large to present here. As can be seen, some industries are better represented than others. There are few audits in SIC 29 (Petroleum Refining and Related Industries) and SIC 31 (Leather and Leather Products). In the case of SIC 31, there may be few plants within the operational limits of the EADCs or a small population in general. Therefore, the sample size may still be acceptable. With SIC 29, the reason for the small sample size is probably attributed to the limitations of the EADC, which limits it to small- to medium-sized plants that can be adequately covered in a one- to two-day site visit. With the sample size a small percent of the industrial population, the statistical significance of the data is reduced.

Table 3.4 identifies the number of recommendations (ECOs) made for each of the electric O&M DIECOs by each industry SIC. This information is also illustrated in Figure 3.2. From this information, certain DIECOs stand out throughout all industry categories. Figure 3.3 illustrates the total number of recommendations made for all industry by DIECO. Twelve DIECOs stand out as the most common recommendations. Figure 3.4 illustrates the total number of recommendations made by industry SIC. This graph is more attributed to the number of audits performed rather than any trend.

For a recommendation to be made and included in an EADC report, and therefore in the database, it must first be applicable to the plant, second not already exist, and third be cost effective for the plant (generally a simple payback of 3 years or less, although there may be exceptions).

Assuming that the EADC attempts to be as thorough and complete as possible, by dividing the number of recommendations in each category by the number of audits performed in that category, a frequency results. Table 3.5 shows this frequency. This is an estimate of the number of times a DIECO may be found to be applicable and cost effective to an industry category. This should not be interpreted as a market penetration, but rather a market potential. Not all EADC recommendations are implemented. The frequency analysis of Table 3.5 is illustrated in Figure 3.5. Here it shows that certain DIECOs stand out as being the most frequent throughout industry. This is better illustrated in Figure 3.6 which shows the frequency for all industry by DIECO.

Energy savings is, of course, an important criteria. Table 3.6 shows the energy savings as a percent of the plant's total electric consumption for each DIECO and each industry SIC. This information is illustrated in Figure 3.7. Figure 3.8 illustrates the percent energy savings for each DIECO averaged across all industry.

Although some DIECOs do stand out as large energy savers, as noted earlier not all DIECOs are applicable in all plants. Table 3.7 combines, through multiplication, the frequencies of Table 3.5 with the percent energy savings of Table 3.6. (For example, if a specific energy measure saves an average 8% of a plant's energy consumption within a specific industry category and is only applicable 25% of the time [1 in 4 plants within that industry category], then the overall potential savings to that industry category is only 2% [8% x 25%]). The result, Table 3.7, is an estimate of the electric O&M energy conservation potential as a percent of total plant electric energy consumption. This information is illustrated in Figure 3.9. Figure 3.10 illustrates this information averaged across all industry for each DIECO. As illustrated in this figure certain DIECOs have a more significant energy-saving potential. Figure 3.11 illustrates the electric O&M energy conservation potential for industry as a percent of the total electric energy consumption for each 2-digit SIC.

The database also includes implementation data collected after the clients have had time to respond to the reports and their recommendations. Table 3.8 shows the average estimated implementation cost per kWh for each DIECO in each industry SIC. This information is based on those ECOs actually implemented, or scheduled for implementation, not the entire database. The numbers, however, are still based on calculated estimates, not metered data or actual costs.

The implementation data can also be used to estimate the potential market penetration of individual DIECOs within the various SICs. Glasser (1992) identifies that implementation rates do vary between SIC categories from 71.2% in the Chemical and Allied Products industry (SIC 28) to 22.9% in the Lumber and Wood Products industry (SIC 24). Implementation rates were not performed for this analysis, because the EADC data consists mostly of individual efforts on behalf of the plant, usually not due to utility DSM program incentives. The existence of an applicable utility DSM or other technical assistance program should improve the resulting implementation rate.

3.3.5 Application at the National Level

Applying the potential energy-savings estimate from Table 3.7 to the national electric energy consumption estimate from Section 2.1, results in the estimate of the national electric O&M energy conservation potential shown in Table 3.9 and illustrated in Figure 3.12. The spikes shown in Figure 3.12 indicate significant potential for energy savings for certain DIECOs and SICs. Figure 3.13 illustrates the national electric O&M energy conservation potential for the various DIECOs totaled

across all industries. Here it is evident that a few DIECOs account for the majority of the total potential energy conservation that can be achieved through O&M techniques. Figure 3.14 illustrates the national electric O&M energy conservation potential for the various industry SICs totalled for all DIECOs. In this figure three industry categories stand out - SIC 28 (Chemicals and Allied Products), SIC 33 (Primary Metals Industry, and SIC 26 (Paper and Allied Products). This is no major revelation since these industries are the most significant energy consumers (a small percent of a large number is still a large number). The total potential may be overestimated, however, because of the limitations to the EADC data described earlier.

Combining the electric O&M energy conservation potential of Table 3.9 with the implementation cost of Table 3.8 results in a supply curve estimate of national energy conservation potential for industrial O&M opportunities as shown in Figure 3.15. This type of supply curve shows the average implementation cost (first cost) versus the annual energy conservation potential (annual savings). Because useful life and persistence of the measure can not be readily assumed, the cost and savings in this figure are not leveled. The result indicates an energy-savings potential of approximately 80 billion kWh/yr (annual savings) with an implementation cost (e.g., one-time repair cost) of \$0.05/kWh and less.

3.3.6 Application to the Pacific Northwest

The information of Table 3.7 can also be applied to the electric energy consumption estimate of the Pacific Northwest presented in Section 2.3 resulting in a regional estimate of the industrial electric O&M energy conservation potential. This information is presented in Table 3.10 and illustrated in Figure 3.16. It is important to note that SIC 3334, Primary Aluminum Industry, is excluded from the baseline. Although the aluminum industry is the largest energy consumer in the Pacific Northwest, that industry is not represented in the EADC database. It is assumed that the results of the EADC analysis for SIC 33 are not representative of the primary aluminum industry (SIC 3334) without introducing a source of significant error.

The spikes illustrated in Figure 3.16 identify the potential for significant energy conservation for specific DIECOs in specific industry categories. The energy conservation potential for each DIECO across all industry SIC codes is illustrated in Figure 3.17. As with the national level analysis, it is evident that a few DIECOs account for the majority of the energy conservation potential. The energy conservation potential for each industry category across all electric O&M DIECOs is illustrated in Figure 3.18. A bit of trepidation should be used in interpreting this illustration. Although SIC 26 (Paper and Allied Products) stands out above the other industry categories, there are a number of mitigating circumstances. First, the paper industry is a major energy consumer in the Pacific Northwest, therefore it may stand to reason that it would also have a large energy conservation potential. However, the paper industry in the Pacific Northwest is very active in improving energy efficiency and reducing waste through active energy programs. Second, the paper industries consist of mostly large facilities. These two factors are potentially in conflict with the limitations noted for the EADC database and are therefore suspect.

Combining the electric O&M energy conservation potential of Table 3.10 with the implementation cost of Table 3.8 results in a supply curve estimate of energy conservation potential in the Pacific Northwest for industrial electric O&M opportunities as shown in Figure 3.19. As with Figure 3.15, this type of supply curve shows the average implementation cost (first cost) versus the

annual energy conservation potential (annual savings). Because useful life and persistence of the measure can not be readily assumed, the cost and savings in this figure are not levelized. The result indicates an annual energy-savings potential of approximately 4.0 billion kWh/yr (456.6 aMW) with an implementation cost (e.g., one-time repair cost) of \$0.05/kWh and less. (For purposes of example, assuming each energy measure in Figure 3.19 has a useful life of three years, 100% persistence over its useful life, no incremental O&M costs, and using an 8% discount rate, the 4.0 billion kWh/yr (456.6 aMW) could be realized with a levelized cost of \$0.0194/kWh and less.)

The DIECO list used in this analysis can be grouped into larger categories of end-use equipment as shown in Table 3.11. This analysis indicates that the largest source of electric O&M energy-savings potential exists with air compressors, followed by motors, lighting, HVAC, and controls.

Figure 3.1. Number of Surveys in EADC Database

Figure 3.2. Number of Recommendations in EADC Database

Figure 3.3. Number of Recommendations by DIECO in EADC Database

Figure 3.4. Number of Recommendations by SIC in EADC Database

Figure 3.6. Frequency of Recommendations by DIECO in EADC Database

Figure 3.8. Average Energy Savings by DIECO Identified in EADC Database

Figure 3.9. Summary of Energy-Savings Potential

Figure 3.10. Summary of Energy-Savings Potential by DIECO

Figure 3.11. Summary of Energy-Savings Potential by SIC

Figure 3.12. National Industrial O&M Energy-Savings Potential

Figure 3.13. National Industrial O&M Energy-Savings Potential by DIECO

Figure 3.14. National Industrial O&M Energy-Savings Potential by SIC

Figure 3.15. Supply Curve of National Industrial O&M Energy-Saving Measures

Figure 3.16. Pacific Northwest Industrial O&M Energy-Savings Potential

Figure 3.17. Pacific Northwest Industrial O&M Energy-Savings Potential by DIECO

Figure 3.18. Pacific Northwest Industrial O&M Energy-Savings Potential by SIC

Figure 3.19. Supply Curve of Pacific Northwest Industrial O&M Energy-Saving Measures

Table 3.1. Industrial Electric O&M Energy-Saving Measures and Potential

Recommendation	Estimated Percent Savings (%)	Industrial End-Use Category	Potential Electricity Savings		Estimated Percent Savings Reference	End-Use Category National References	End-Use Category PNW Region References
			National (million kWh/yr)	PNW (million kWh/yr)			
Total Energy Management Program	30.00	All	253,110	17,794	Lewis 1991	Resource Dynamics Corp. 1992a	Table 2.5
General Proper Maintenance of Electromechanical Systems	12.50	All	105,463	7,414	Ibáñez 1978	Resource Dynamics Corp. 1992a	Table 2.5
Employee Participation Program	19.00	All	180,303	11,269	Weaver 1984	Resource Dynamics Corp. 1992a	Table 2.5
O&M Program - School Case Study	37.00	n/a	n/a	n/a	Lewis 1991	None	None
General Air Compressor O&M	12.59	Compressors	8,720	418	Singh et al. 1990	Resource Dynamics Corp. 1992b	Table 2.5
Reduce Compressed Air Leaks	27.50	Compressors	19,046	906	Patel 1991	Resource Dynamics Corp. 1992b	Table 2.5
Reduce Compressed Air Leaks	5.00	Compressors	3,463	165	Singh et al. 1990	Resource Dynamics Corp. 1992b	Table 2.5
Relocate Compressed Air Intake to Outside	3.50	Compressors	2,424	116	Singh et al. 1990	Resource Dynamics Corp. 1992b	Table 2.5
General Air Conditioning O&M	30.00	Chillers	13,786	522	Neal 1992	Battelle-Columbus Division 1988a and Resource Dynamics Corp. 1992a	Battelle-Columbus Division 1988 and Table 2.4
Clean A/C Filters	8.00	Chillers	3,678	139	Neal 1992	Battelle-Columbus Division 1988a and Resource Dynamics Corp. 1992a	Battelle-Columbus Division 1988 and Table 2.4
Install Industrial Refrigeration Controls	10.00	SIC 20-Refrig.	201	52	Nadel et al. 1991	Resource Dynamics Corp. 1992a	Cilano et al. 1988 and Table 2.4
Install Fast Controllers on Compressors	20.00	Compressors	13,852	661	Lovins et al. 1989	Resource Dynamics Corp. 1992b	Table 2.5
Install Sequential Lead/Lag Controllers	20.00	Compressors	13,852	661	Nadel et al. 1991	Resource Dynamics Corp. 1992b	Table 2.5
Install Sequential Lead/Lag Controllers	10.00	Pumps	12,406	697	Nadel et al. 1991	Resource Dynamics Corp. 1992b	Table 2.5
Use Improved Lubricant	3.33	Motors	19,344	1,256	Kenick 1979	Resource Dynamics Corp. 1992a	Table 2.5
Use Improved Lubricant	5.00	Motors	29,045	1,886	PPX 1992	Resource Dynamics Corp. 1992a	Table 2.5
Do Not Over-lubricate Motors	0.36	Motors	2,178	143	Lovins et al. 1989	Resource Dynamics Corp. 1992a	Table 2.5
Improve Bearings, Lubricant and Lube Maint.	0.63	Motors	3,631	236	Lovins et al. 1989	Resource Dynamics Corp. 1992a	Table 2.5
Use Premium Lubricants	11.50	Motors	66,804	4,339	Nadel et al. 1991	Resource Dynamics Corp. 1992a	Table 2.5
Use Improved Lubricants in Gearboxes	10.00	Motors (20%) (a)	11,618	755	Lovins et al. 1989	Resource Dynamics Corp. 1992a and Lovins et al. 1989	Table 2.5 and Lovins et al. 1989
Improved Lubricant - Wire Drawing Process	9.00	unknown	n/a	n/a	Smith 1978	None	None
Replace V-belts with Cogged V-belts	2.70	Motors (34%) (b)	5,333	346	Lovins et al. 1989	Resource Dynamics Corp. 1992a and Lovins et al. 1989	Table 2.5 and Lovins et al. 1989
Replace V-belts with Synchronous Belts	3.80	Motors (34%) (b)	7,505	487	Lovins et al. 1989	Resource Dynamics Corp. 1992a and Lovins et al. 1989	Table 2.5 and Lovins et al. 1989
Improve Maintenance on V-belt Drives	3.00	Motors (34%) (b)	5,925	385	Lovins et al. 1989	Resource Dynamics Corp. 1992a and Lovins et al. 1989	Table 2.5 and Lovins et al. 1989
Correct Voltage Imbalance	1.70	Motors	9,875	641	Lovins et al. 1989	Resource Dynamics Corp. 1992a	Table 2.5
Apply Correct Voltage to Motors	3.30	Motors	19,170	1,245	Lovins et al. 1989	Resource Dynamics Corp. 1992a	Table 2.5
Reduce Operating Voltage 1%	0.41	Motors	2,382	155	Lovins et al. 1989	Resource Dynamics Corp. 1992a	Table 2.5
Electrical Tune Up of Motor Systems	8.00	Motors	46,472	3,018	Nadel et al. 1991	Resource Dynamics Corp. 1992a	Table 2.5
Improved Motor Use and Scheduling	3.50	Motors	20,332	1,320	Ibáñez 1978	Resource Dynamics Corp. 1992a	Table 2.5
Turn Off Motor Heaters During Operation	0.09	Motors	505	34	Lovins et al. 1989	Resource Dynamics Corp. 1992a	Table 2.5
Turn Off Idling Motors	0.43	Motors	2,498	162	Lovins et al. 1989	Resource Dynamics Corp. 1992a	Table 2.5
Provide Better Motor Cooling	0.09	Motors	505	34	Lovins et al. 1989	Resource Dynamics Corp. 1992a	Table 2.5

(a) Competittek (Lovins et al. 1989) estimates that 20% of the motor population utilizes gearboxes.

(b) Competittek (Lovins et al. 1989) estimates that 34% of the motor population utilizes V-belts.

Table 3.2. Industrial Electric O&M Measures by DIECO

DIECO	DIECO Name
3121	De-energize excess transformer capacity to avoid utility charges
3141	Reduce load on electric conductors to reduce heat losses
3211	Reduce the pressure of compressed air system to the minimum required
3213	Reduce use of compressed air to minimum/use smaller compressor
3221	Install compressor air intake in coolest location
3231	Eliminate leaks in lines and valves carrying compressed air or other gases
3232	Remove or close off unneeded compressed air lines to eliminate leaks
3243	Install, clean or replace compressor air filters regularly
3311	Use minimum water for processes; cooling, washing, etc.
3312	Shut off cooling water when not required
3342	Operate cooling towers at constant outlet temperature to avoid sub-cooling
3351	Eliminate leaks in water lines, valves, storage tanks, and process equip.
3352	Remove or close off unneeded water lines to avoid potential leaks/freezing
4111	Shut down equipment when not in use or setback its temperature
4112	Reduce operating time of equipment to the minimum required/install timers
4113	Turn off conveyers when not in use
4115	Install controls to operate equipment only when loaded
4121	Use most efficient equipment at its maximum capacity
4122	Schedule to run equipment with full loads/use batch type drying ovens
4125	Schedule baking times of small and large components to minimize energy use
4131	Reduce temperature or power requirement of process equipment on standby
4132	Minimize operation of equipment required to be kept in standby condition
4141	Locate causes of demand charges and reschedule operations to avoid peak
4142	Recharge batteries (fork trucks, etc.) during off-peak demand periods
4222	Overlap custodial work hours with normal day hours
4312	Evaluate energy use in packaging process/change to reduce energy-intensity
4321	Upgrade or repair and maintain conveyers
5121	Establish equipment maintenance schedule for or make necessary repairs
5122	Improve lubrication practices for motor driven equipment
5123	Adjust or modify vents on process equipment to minimize energy usage

Table 3.2. (contd)

DIECO	DIECO Name
5213	Avoid cooling process streams which subsequently must be heated, etc.
5214	Reduce flow rate of process fluids (e.g drying air)
5218	Use optimum temperature for hot processes – washing, drying, forming, etc.
5221	Convert from batch to continuous operation
5222	Use small number of high-output units vs. many small inefficient units
5224	Reduce scrap production
5311	Use minimum safe oven ventilation
5331	Use optimum refrigerator thickness insulation for low temperatures
5333	Reduce infiltration to refrigerated areas/isolated hot process equipment
5335	Use highest acceptable temperature for process chilling or cold storage
5336	Modify refrigeration system to enable compressor to operate at low pressure
5338	Eliminate or reduce frost formation on refrigerator evaporators
5339	Minimize the temperature of refrigeration condenser cooling water
5341	Reduce temperature of service or domestic hot water
5355	Use energy-efficient belts and other improved mechanisms
5511	Insulate tanks, vessels, lines, and process equipment
5512	Increase or repair insulation thickness or process tanks, vessels, lines
5514	Cover and seal open tanks
5521	Use minimum necessary ventilation for process purposes
5525	Isolate hot/cold equipment from manufacturing areas to minimize HVAC
6111	Disconnect lighting fixtures, delamp, or use lower output lamps for min. light needed
6112	Reduce lighting where natural light is available/install skylights
6114	Disconnect ballasts
6121	Install timers or motion sensors on little used lights or initiate schedule
6122	Rewire for light shutoff in little used areas or where daylight present
6125	Improve reflectance of walls and ceilings/add fixture reflectors/clean fixt
6126	Reduce exterior lighting to minimum safe levels
6211	Close doors, windows and loading doors in space conditioned areas
6212	Repair or replace broken windows, sashes, doors etc./plug cracks
6213	Seal unnecessary dampers, flues, louvers, and other wall and roof openings

Table 3.2. (contd)

DIECO	DIECO Name
6214	Install weather stripping on loose-fitting windows and doors
6215	Install door seals, plastic strip doors or air curtains at loading docks
6231	Reduce outside air for ventilation except with economizer/recycle HVAC
6232	Reduce ventilation air to minimum safe levels
6236	Clean or replace air filters regularly
6237	Replace high-resistance grills, ducts, etc. with properly sized fittings
6238	Centralize control of exhaust fans to ensure shutdown or establish program
6241	Keep space temperature lower during heating season, higher during cooling
6242	Minimize areas where space is conditioned/isolate cooler areas from warmer
6243	Reduce heating/shut air conditioning manually when building is unoccupied
6244	Install or use timers or thermostats for space conditioning
6245	Separate controls of air handlers from controls of A/C and heating
6246	Close outdoor air dampers during warm-up or cool-down periods
6247	Establish HVAC equipment maintenance schedules
6249	Use water sparingly on air conditioning exchanger to improve heat transfer
6255	Install or upgrade insulation on HVAC distribution systems (pipes, ducts, etc.)
6272	Shut steam or hot water lines to space heating units during mild weather
6273	Modify air conditioning system to enable air compressor to operate at lower
6312	Clean or repair air conditioning refrigerant condensers
6313	Use water coolers and vending machines efficiently

Table 3.3. Number of Surveys in EADC Database

EADC	Industry SIC Number																			Total
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
Colorado State University	45	0	0	5	2	5	20	3	2	10	0	13	4	17	18	9	5	9	3	170
Georgia Tech	34	85	13	13	4	9	9	10	0	30	1	4	11	20	17	9	7	7	3	298
Louisiana Tech	19	3	3	26	1	8	1	1	4	19	0	9	17	9	8	4	8	1	2	143
North Carolina A&T State Univ.	11	18	12	8	14	4	3	5	0	10	0	5	7	9	6	5	4	3	2	126
Oklahoma State University	33	2	11	2	7	8	15	9	3	23	0	16	19	60	42	14	8	10	3	285
Oregon State University	34	1	0	22	0	1	3	2	0	1	0	0	2	1	3	4	0	1	0	75
Prairie View University	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	6
Rutgers University	3	0	2	0	2	11	2	7	0	18	0	5	6	10	2	4	1	1	1	75
Stevens Institute of Technology	4	1	5	1	1	2	6	6	0	8	1	2	9	17	5	7	0	2	3	80
Texas A&M University	9	1	0	7	1	6	3	5	1	6	0	0	3	14	12	1	3	2	1	75
Tri-State University	2	0	0	0	1	0	1	1	0	7	0	0	2	9	1	2	0	0	0	26
University of Dayton	20	5	8	6	8	15	14	18	1	26	2	7	17	46	52	19	11	4	5	284
University of Kansas	36	0	15	8	7	27	32	17	2	23	2	6	9	24	30	20	13	8	2	261
University of Massachusetts	11	9	0	2	0	16	2	8	0	26	0	4	20	26	13	14	3	9	5	170
University of Tennessee	37	17	26	8	12	15	2	10	4	20	5	14	13	25	21	24	14	9	9	265
University of Wisconsin	8	1	0	1	3	5	1	3	0	4	2	0	8	14	15	5	3	0	2	75
Total	306	143	65	108	63	132	114	105	17	233	13	85	147	307	245	141	80	66	41	2,442

Table 3.4. Number of Recommendations in EADC Database

DIECO	Industry SIC Number																			Total
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
3121	1	0	0	0	0	0	1	0	0	0	0	0	0	2	2	2	1	2	0	11
3141	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	1	0	0	4
3211	36	17	20	5	8	23	16	13	3	24	1	8	10	30	18	16	4	10	2	264
3213	12	1	1	0	0	4	5	3	0	5	0	3	6	7	5	5	4	2	0	63
3221	78	46	11	21	29	43	39	31	3	68	5	20	47	98	56	43	19	17	7	661
3231	50	15	25	48	28	38	25	21	3	66	4	30	45	138	89	44	28	18	22	737
3232	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	3
3243	0	0	1	0	0	0	1	1	0	5	1	1	1	1	3	0	0	1	0	16
3311	2	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	4
3312	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2
3342	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	3
3351	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	5
3352	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
4111	6	0	1	1	2	5	6	2	0	10	1	2	4	4	8	7	6	3	0	69
4112	9	6	6	17	15	16	13	6	0	40	2	10	25	36	26	12	7	12	6	266
4113	2	0	0	0	0	1	1	0	0	0	0	1	2	0	0	0	0	0	0	7
4115	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2
4121	6	1	2	0	1	1	4	3	0	4	0	4	4	9	4	2	2	0	0	47
4122	0	0	2	1	1	2	0	0	0	7	0	0	0	3	2	1	0	0	1	20
4125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2
4131	0	0	0	0	0	1	0	0	0	3	0	0	2	2	0	0	1	0	0	9
4132	0	0	1	0	0	1	0	1	0	3	1	0	0	1	1	3	0	0	0	12
4141	18	5	4	6	4	8	12	10	2	26	0	4	15	43	45	12	13	8	1	236
4142	11	0	0	0	1	1	2	1	0	2	0	0	2	5	6	1	0	0	0	32
4222	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
4312	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4321	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5121	0	2	1	0	0	0	0	1	0	1	0	2	0	0	0	1	1	0	0	9
5122	48	19	10	14	15	40	20	21	2	35	3	13	25	48	33	15	8	8	4	363
5123	0	0	0	1	0	0	0	0	0	1	0	1	0	2	0	0	0	0	1	6
5213	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
5214	0	0	0	2	0	1	0	0	0	0	0	1	0	1	2	0	0	1	0	6
5216	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	3
5221	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5222	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	1	0	0	0	5
5224	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
5311	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	1	0	1	1	7
5331	5	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	9
5333	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	17
5335	4	0	0	0	0	0	1	0	0	3	0	0	0	1	0	0	0	1	0	10

Table 3.4. (contd)

DIECO	Industry SIC Number																			Total
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
5336	36	1	0	0	0	0	4	2	0	2	0	0	0	0	0	1	0	0	0	46
5338	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5339	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
5341	4	0	5	6	2	10	13	4	1	13	0	1	8	20	16	14	3	2	3	125
5355	121	43	23	45	22	39	37	24	6	50	3	27	47	75	42	26	19	10	5	664
5511	28	6	11	2	2	14	10	7	0	90	2	3	15	17	21	24	7	13	3	275
5512	0	0	2	0	0	0	0	0	0	6	0	1	1	0	1	2	0	0	0	13
5514	0	0	0	0	0	0	0	0	0	0	0	0	3	5	1	4	0	2	0	15
5521	0	0	0	2	4	2	1	3	0	3	0	0	1	4	4	3	5	2	0	34
5525	1	1	2	0	0	0	1	0	0	3	0	0	0	0	1	0	0	0	0	9
6111	18	8	18	6	6	7	17	8	0	20	1	6	3	33	30	20	10	11	6	226
6112	4	1	3	6	1	5	3	5	1	14	1	3	5	7	9	6	11	0	1	88
6114	0	3	1	0	2	0	0	0	0	2	0	0	0	1	2	1	1	1	0	14
6121	45	10	15	13	5	20	7	12	3	25	4	9	14	38	24	15	11	9	3	282
6122	6	3	3	2	1	5	4	3	0	6	1	0	3	7	5	4	4	1	1	59
6125	3	5	3	1	1	1	1	1	0	2	2	2	1	1	10	2	4	2	4	46
6126	5	1	1	3	0	1	0	4	0	1	0	2	1	6	4	4	2	1	0	36
6211	2	0	3	0	0	0	1	0	0	1	0	0	0	1	1	1	3	0	0	13
6212	2	0	1	0	0	0	3	1	0	0	0	0	1	2	0	1	1	0	0	12
6213	1	0	2	1	0	1	3	2	0	0	0	0	0	2	1	2	1	2	1	19
6214	5	0	2	0	0	0	5	0	0	0	1	0	0	2	1	6	2	1	2	27
6215	6	2	2	0	0	0	7	0	0	2	0	0	0	2	6	2	1	1	1	32
6231	0	1	0	1	0	2	3	2	0	4	0	0	0	1	1	6	2	3	0	26
6232	0	0	0	1	1	6	7	1	0	7	0	0	1	6	10	8	1	3	2	54
6236	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	1	1	0	0	6
6237	0	0	1	0	0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	5
6238	1	0	0	0	1	1	2	0	0	2	0	0	0	4	3	2	1	1	0	18
6241	4	3	3	0	2	6	11	3	0	6	0	2	3	8	7	6	6	3	1	74
6242	5	0	2	0	1	2	3	1	0	3	0	0	2	7	2	2	2	2	1	35
6243	0	0	1	1	1	2	2	0	0	1	0	1	1	6	0	1	2	0	0	19
6244	35	5	14	11	4	15	29	13	4	26	0	8	8	29	33	20	12	8	5	262
6245	0	0	1	0	0	0	1	1	0	2	0	0	0	0	0	2	0	1	0	8
6246	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
6247	1	0	1	0	0	3	5	0	0	1	0	0	0	1	4	0	2	1	0	19
6249	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
6255	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3
6272	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6273	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
6312	0	1	0	0	1	0	2	1	0	0	0	0	0	0	1	0	0	1	0	7
6313	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	2	0	0	0	5
Total	639	207	213	217	162	333	334	214	29	613	33	167	306	723	552	361	212	167	84	5,506

Table 3.5. Frequency of Recommendations in EADC Database (%)

DIECO	Industry SIC Number																			Average(s)
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
3121	0.33	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.82	1.42	1.25	3.03	0.00	1.20
3141	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.85	0.00	0.00	1.25	0.00	0.00	0.78
3211	11.78	11.88	21.05	4.58	12.70	17.42	14.04	12.38	17.85	10.30	7.88	9.41	8.80	8.77	7.35	11.35	5.00	15.15	4.88	11.11
3213	3.92	0.70	1.05	0.00	0.00	3.03	4.39	2.88	0.00	2.15	0.00	3.53	4.08	2.28	2.04	3.55	5.00	3.03	0.00	2.97
3221	25.48	32.17	11.58	19.27	46.03	32.58	34.21	29.52	17.85	29.18	38.48	23.53	31.97	31.92	22.88	30.50	23.75	25.76	17.07	27.55
3231	16.34	10.48	28.32	44.04	44.44	28.78	21.83	20.00	17.85	28.33	30.77	35.28	30.81	44.95	38.33	31.21	35.00	27.27	53.88	30.71
3232	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.53
3243	0.00	0.00	1.05	0.00	0.00	0.00	0.88	0.85	0.00	2.15	7.88	1.18	0.88	0.33	1.22	0.00	0.00	1.52	0.00	1.78
3311	0.85	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
3312	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
3342	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.82	0.00	0.00	0.00	0.00	0.82
3351	0.33	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.41	0.00	1.25	0.00	0.00	0.88
3352	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43
4111	1.98	0.00	1.05	0.82	3.17	3.78	5.28	1.80	0.00	4.28	7.88	2.35	2.72	1.30	3.87	4.88	7.50	4.55	0.00	3.57
4112	2.94	4.20	8.32	15.80	23.81	12.12	11.40	5.71	0.00	17.17	15.38	11.78	17.01	11.73	11.43	8.51	8.75	18.18	14.83	12.04
4113	0.85	0.00	0.00	0.00	0.00	0.78	0.88	0.00	0.00	0.00	0.00	1.18	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.97
4115	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58
4121	1.98	0.70	2.11	0.00	1.58	0.78	3.51	2.88	0.00	1.72	0.00	4.71	2.72	2.83	1.83	1.42	2.50	0.00	0.00	2.22
4122	0.00	0.00	2.11	0.82	1.58	1.52	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.98	0.82	0.71	0.00	0.00	2.44	1.58
4125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.71	0.00	0.00	0.00	0.58
4131	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	1.28	0.00	0.00	1.38	0.85	0.00	0.00	1.25	0.00	0.00	1.08
4132	0.00	0.00	1.05	0.00	0.00	0.78	0.00	0.95	0.00	1.28	7.88	0.00	0.00	0.33	0.41	2.13	0.00	0.00	0.00	1.83
4141	5.88	3.50	4.21	5.50	8.35	8.08	10.53	9.52	11.78	12.02	0.00	4.71	10.20	14.01	18.37	8.51	18.25	12.12	2.44	9.00
4142	3.58	0.00	0.00	0.00	1.58	0.78	1.75	0.95	0.00	0.88	0.00	0.00	1.38	1.83	2.45	0.71	0.00	0.00	0.00	1.57
4222	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.33
4312	0.00	0.00	1.05	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81
4321	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78
5121	0.00	1.40	1.05	0.00	0.00	0.00	0.00	0.95	0.00	0.43	0.00	2.35	0.00	0.00	0.00	0.71	1.25	0.00	0.00	1.18
5122	15.88	13.28	10.53	12.84	23.81	30.30	17.54	20.00	11.78	15.02	23.08	15.28	17.01	15.84	13.47	10.84	11.25	13.84	9.78	15.82
5123	0.00	0.00	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.43	0.00	1.18	0.00	0.85	0.00	0.00	0.00	0.00	2.44	1.12
5213	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43
5214	0.00	0.00	0.00	1.83	0.00	0.78	0.00	0.00	0.00	0.00	0.00	1.18	0.00	0.33	0.82	0.00	0.00	1.52	0.00	1.07
5218	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.42	0.00	0.00	0.00	1.18
5221	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
5222	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.43	0.00	0.00	0.00	0.33	0.41	0.71	0.00	0.00	0.00	0.55
5224	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.71
5311	0.00	0.70	1.05	0.00	1.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.71	0.00	1.52	2.44	1.18
5331	1.83	0.00	0.00	0.00	0.00	0.00	0.88	0.95	5.88	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.88
5333	4.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	1.52	0.00	2.58
5335	1.31	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	1.29	0.00	0.00	0.00	0.33	0.00	0.00	0.00	1.52	0.00	1.08

Table 3.5. (contd)

DIECO	Industry SIC Number																			Average(s)
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
5336	11.76	0.70	0.00	0.00	0.00	0.00	3.51	1.90	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	3.24
5338	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
5339	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
5341	1.31	0.00	5.26	5.50	3.17	7.58	11.40	3.81	5.88	5.58	0.00	1.18	5.44	6.51	6.53	9.93	3.75	3.03	7.32	5.18
5355	39.54	30.07	24.21	41.28	34.92	29.55	32.46	22.86	35.29	21.46	23.08	31.76	31.97	24.43	17.14	18.44	23.75	15.15	12.20	26.82
5511	9.15	4.20	11.58	1.83	3.17	10.61	8.77	6.67	0.00	38.63	15.38	3.53	10.20	5.54	8.57	17.02	8.75	19.70	7.32	10.59
5512	0.00	0.00	2.11	0.00	0.00	0.00	0.00	0.00	0.00	2.58	0.00	1.18	0.68	0.00	0.41	1.42	0.00	0.00	0.00	1.39
5514	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04	1.63	0.41	2.84	0.00	3.03	0.00	1.99
5521	0.00	0.00	0.00	1.83	6.35	1.52	0.88	2.86	0.00	1.29	0.00	0.00	0.68	1.30	1.63	2.13	6.25	3.03	0.00	2.48
5525	0.33	0.70	2.11	0.00	0.00	0.00	0.88	0.00	0.00	1.29	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.95
6111	5.88	5.59	18.95	5.50	9.52	5.30	14.91	7.62	0.00	8.58	7.69	7.06	2.04	10.75	12.24	14.18	12.50	16.67	14.63	9.98
6112	1.31	0.70	3.16	5.50	1.59	3.79	2.63	4.76	5.88	6.01	7.69	3.53	3.40	2.28	3.67	4.26	13.75	0.00	2.44	4.24
6114	0.00	2.10	1.05	0.00	3.17	0.00	0.00	0.00	0.00	0.86	0.00	0.00	0.00	0.33	0.82	0.71	1.25	1.52	0.00	1.31
6121	14.71	6.99	15.79	11.93	7.94	15.15	6.14	11.43	17.65	10.73	30.77	10.59	9.52	12.38	9.80	10.64	13.75	13.64	7.32	12.47
6122	1.96	2.10	3.16	1.83	1.59	3.79	3.51	2.86	0.00	2.58	7.69	0.00	2.04	2.28	2.04	2.84	5.00	1.52	2.44	2.89
6125	0.86	3.50	3.16	0.92	1.59	0.76	0.88	0.95	0.00	0.86	15.38	2.35	0.68	0.33	4.08	1.42	5.00	3.03	9.76	3.09
6126	1.63	0.70	1.05	2.75	0.00	0.76	0.00	3.81	0.00	0.43	0.00	2.35	0.68	1.95	1.63	2.84	2.50	1.52	0.00	1.76
6211	0.65	0.00	3.16	0.00	0.00	0.00	0.88	0.00	0.00	0.43	0.00	0.00	0.00	0.33	0.41	0.71	3.75	0.00	0.00	1.29
6212	0.65	0.00	1.05	0.00	0.00	0.00	2.63	0.95	0.00	0.00	0.00	0.00	0.68	0.65	0.00	0.71	1.25	0.00	0.00	1.07
6213	0.33	0.00	2.11	0.92	0.00	0.76	2.63	1.90	0.00	0.00	0.00	0.00	0.00	0.65	0.41	1.42	1.25	3.03	2.44	1.49
6214	1.63	0.00	2.11	0.00	0.00	0.00	4.39	0.00	0.00	0.00	7.69	0.00	0.00	0.65	0.41	4.26	2.50	1.52	4.88	2.73
6215	1.96	1.40	2.11	0.00	0.00	0.00	6.14	0.00	0.00	0.86	0.00	0.00	0.00	0.65	2.45	1.42	1.25	1.52	2.44	2.02
6231	0.00	0.70	0.00	0.92	0.00	1.52	2.63	1.90	0.00	1.72	0.00	0.00	0.00	0.33	0.41	4.26	2.50	4.55	0.00	1.95
6232	0.00	0.00	0.00	0.82	1.59	4.55	6.14	0.95	0.00	3.00	0.00	0.00	0.68	1.95	4.08	5.87	1.25	4.55	4.88	3.09
6236	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.43	0.00	1.18	0.00	0.00	0.41	0.71	1.25	0.00	0.00	0.79
6237	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	1.18	0.00	0.00	0.41	0.71	0.00	0.00	0.00	0.76
6238	0.33	0.00	0.00	0.00	1.59	0.76	1.75	0.00	0.00	0.86	0.00	0.00	0.00	1.30	1.22	1.42	1.25	1.52	0.00	1.20
6241	1.31	2.10	3.16	0.00	3.17	4.55	9.95	2.86	0.00	2.58	0.00	2.35	2.04	2.61	2.86	4.26	7.50	4.55	2.44	3.62
6242	1.63	0.00	2.11	0.00	1.59	1.52	2.63	0.95	0.00	1.29	0.00	0.00	1.36	2.28	0.82	1.42	2.50	3.03	2.44	1.83
6243	0.00	0.00	1.05	0.92	1.59	1.52	1.75	0.00	0.00	0.43	0.00	1.18	0.68	1.95	0.00	0.71	2.50	0.00	0.00	1.30
6244	11.44	3.50	14.74	10.09	6.35	11.36	25.44	12.38	23.53	12.45	0.00	9.41	5.44	9.45	13.47	14.18	15.00	12.12	12.20	12.36
6245	0.00	0.00	1.05	0.00	0.00	0.00	0.88	0.95	0.00	0.86	0.00	0.00	0.00	0.00	0.00	1.42	0.00	1.52	0.00	1.11
6246	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.41
6247	0.33	0.00	1.05	0.00	0.00	2.27	4.39	0.00	0.00	0.43	0.00	0.00	0.00	0.33	1.63	0.00	2.50	1.52	0.00	1.60
6249	0.00	0.00	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	1.22
6255	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.42	0.00	0.00	0.00	1.24
6272	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
6273	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
6312	0.00	0.70	0.00	0.00	1.59	0.00	1.75	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00	1.52	0.00	1.15
6313	0.00	0.00	1.05	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	1.42	0.00	0.00	0.00	0.89
Average(s)	5.22	5.57	5.10	7.96	9.18	6.31	6.37	5.82	15.51	4.70	14.93	7.02	6.71	4.81	4.80	5.12	6.63	6.84	6.54	3.50

(a) Zero implies no data and is not included in average

Table 3.6. Average Energy Savings Identified in EADC Database (%)

DIECO	Industry SIC Number																			Average(a)
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
3121	0.84	0.00	0.00	0.00	0.00	0.00	2.88	0.00	0.00	0.00	0.00	0.00	0.00	12.18	1.28	8.57	0.00	4.41	0.00	4.81
3141	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.85	0.00	0.00	0.00	15.78	0.00	0.00	0.38	0.00	0.00	8.98
3211	2.45	2.38	8.28	5.74	2.88	4.34	3.01	2.78	1.75	3.82	7.28	3.61	2.58	8.04	5.25	2.88	3.41	2.41	8.18	4.35
3213	5.00	1.42	3.28	0.00	0.00	2.72	8.18	9.07	0.00	7.24	0.00	2.88	8.75	10.34	8.48	18.28	8.78	1.00	0.00	8.10
3221	1.28	1.47	1.83	1.38	4.04	1.87	1.22	1.78	1.10	1.88	1.32	2.21	1.87	2.08	4.75	1.47	1.48	0.83	1.31	1.82
3231	4.78	8.31	10.20	14.00	15.21	7.48	4.28	6.73	11.33	9.82	9.37	8.80	11.08	14.05	9.48	8.51	10.04	5.14	10.20	8.18
3232	0.00	0.00	0.00	0.00	0.00	8.27	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	2.35	0.00	0.00	0.00	0.00	4.01
3243	0.00	0.00	1.72	0.00	0.00	0.00	0.41	2.54	0.00	1.74	1.18	2.08	0.05	1.33	8.78	0.00	0.00	4.81	0.00	2.57
3311	5.18	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	14.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.88
3312	0.00	0.00	0.00	0.00	0.00	0.00	4.81	0.00	0.00	11.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.27
3342	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.82	0.00	0.00	0.00	0.00	8.38	0.00	0.00	0.00	0.00	5.50
3381	0.80	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	2.85	0.00	0.00	0.00	0.00	3.71	0.00	8.55	0.00	0.00	2.88
3382	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48
4111	4.83	0.00	5.88	2.17	15.50	2.12	5.17	48.14	0.00	8.83	2.88	8.58	18.87	8.55	2.88	5.23	5.48	2.38	0.00	8.88
4112	2.40	7.83	4.23	5.18	10.08	8.01	3.87	11.42	0.00	13.82	3.17	27.05	2.58	4.82	7.77	8.82	3.84	3.34	9.45	7.41
4113	0.55	0.00	0.00	0.00	0.00	0.18	1.31	0.00	0.00	0.00	0.00	0.84	12.83	0.00	0.00	0.00	0.00	0.00	0.00	3.13
4118	0.00	0.00	0.00	0.00	0.00	7.88	0.00	0.00	0.00	2.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.28
4121	8.30	8.30	15.83	0.00	15.08	8.28	9.80	14.27	0.00	6.38	0.00	12.55	3.18	15.08	18.08	18.88	4.88	0.00	0.00	10.77
4122	0.00	0.00	48.02	13.80	5.82	12.78	0.00	0.00	0.00	17.80	0.00	0.00	0.00	4.88	4.34	4.58	0.00	0.00	1.81	12.84
4125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.82	0.83	0.00	0.00	0.00	7.38
4131	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	1.83	0.00	0.00	25.13	18.85	0.00	0.00	43.88	0.00	0.00	17.87
4132	0.00	0.00	1.08	0.00	0.00	8.85	0.00	3.81	0.00	3.07	13.45	0.00	0.00	3.80	2.47	8.13	0.00	0.00	0.00	5.48
4141	0.18	0.00	0.08	0.84	0.00	0.78	0.01	0.00	8.52	2.12	0.00	0.00	0.00	1.13	0.11	2.55	0.40	0.02	0.00	1.13
4142	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.34
4222	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.57	0.00	0.00	0.00	0.00	0.00	5.57
4312	0.00	0.00	7.42	0.00	0.00	8.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.41
4321	0.00	0.00	0.00	0.00	0.00	17.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.47
5121	0.00	2.23	3.30	0.00	0.00	0.00	0.00	9.87	0.00	0.52	0.00	7.84	0.00	0.00	0.00	18.88	4.24	0.00	0.00	8.38
5122	7.83	4.32	3.32	10.88	2.78	7.84	4.83	5.51	14.87	5.82	11.75	8.51	8.20	7.15	7.72	4.88	2.41	2.32	2.52	8.52
5123	0.00	0.00	0.00	8.12	0.00	0.00	0.00	0.00	0.00	1.08	0.00	4.34	0.00	7.78	0.00	0.00	0.00	0.00	8.53	4.48
5213	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
5214	0.00	0.00	0.00	31.24	0.00	4.38	0.00	0.00	0.00	0.00	0.00	8.80	0.00	7.48	15.78	0.00	0.00	0.50	0.00	11.48
5218	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.91	0.00	0.00	0.00	4.91
5221	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28
5222	0.00	0.00	0.00	0.00	0.00	0.00	7.03	0.00	0.00	58.08	0.00	0.00	0.00	3.80	7.02	8.55	0.00	0.00	0.00	18.88
5224	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.00	0.00	0.00	1.23
5311	0.00	11.28	7.88	0.00	10.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.84	0.00	4.80	0.00	4.83	11.78	7.88
5331	3.80	0.00	0.00	0.00	0.00	0.00	3.42	0.23	8.10	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.28
5333	3.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28	0.43	0.00	1.85
5335	15.08	0.00	0.00	0.00	0.00	0.00	4.47	0.00	0.00	7.10	0.00	0.00	0.00	0.89	0.00	0.00	0.00	8.88	0.00	8.81

Table 3.6. (contd)

DNECO	Industry SIC Number																			Average(a)
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
5336	11.53	6.06	0.00	0.00	0.00	0.00	8.05	22.35	0.00	4.53	0.00	0.00	0.00	0.00	0.00	3.44	0.00	0.00	0.00	9.33
5338	16.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.85
5339	0.00	0.00	0.00	0.00	0.00	0.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80
5341	0.82	0.00	4.30	3.51	2.76	0.70	2.58	0.86	0.80	0.54	0.00	3.19	0.84	1.20	2.00	1.76	1.37	3.93	3.63	2.02
5355	3.81	4.01	1.66	4.77	2.83	4.81	4.97	3.77	6.70	3.02	4.83	3.15	3.59	3.72	2.96	2.81	3.08	2.51	3.19	3.08
5511	3.11	5.02	4.04	2.99	19.70	3.20	4.42	10.48	0.00	6.73	6.47	8.26	4.33	4.74	7.05	8.57	2.25	4.79	11.32	6.53
5512	0.00	0.00	32.69	0.00	0.00	0.00	0.00	0.00	0.00	6.08	0.00	1.26	0.43	0.00	3.71	7.93	0.00	0.00	0.00	8.68
5514	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.59	5.21	6.31	11.38	0.00	7.32	0.00	7.36
5521	0.00	0.00	0.00	53.28	11.32	31.21	3.93	3.95	0.00	0.90	0.00	0.00	5.15	0.13	3.74	4.62	3.61	0.29	0.00	10.17
5525	2.06	10.06	6.65	0.00	0.00	0.00	6.32	0.00	0.00	1.85	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.00	4.62
6111	6.36	12.82	19.06	10.11	17.62	11.74	4.18	5.81	0.00	4.99	26.46	6.54	10.01	10.40	9.00	15.13	22.79	18.37	18.94	12.80
6112	0.58	2.39	15.71	6.57	2.57	5.58	11.05	2.94	0.84	6.41	21.58	3.24	11.39	19.89	10.22	5.69	14.02	0.00	48.18	10.48
6114	0.00	1.94	7.83	0.00	2.66	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.00	1.70	8.23	0.66	0.66	0.66	0.00	2.80
6121	4.08	10.09	17.83	5.68	4.45	5.68	3.07	4.73	5.31	6.04	19.39	1.36	4.73	5.92	5.31	4.84	4.20	3.16	6.29	6.43
6122	11.50	3.19	16.70	3.51	18.51	4.56	9.62	5.83	0.00	3.86	6.93	0.00	1.68	5.27	9.51	13.20	13.29	34.78	4.00	9.99
6125	27.34	11.78	13.29	5.90	32.39	71.48	6.32	19.12	0.00	12.39	10.08	1.26	19.12	6.13	18.24	29.43	11.80	6.92	8.65	17.32
6126	1.82	0.56	2.94	4.17	0.00	0.14	0.00	1.83	0.00	0.38	0.00	1.64	1.51	4.53	2.55	0.82	1.21	0.35	0.00	1.75
6211	3.73	0.00	1.16	0.00	0.00	0.00	0.14	0.00	0.00	3.36	0.00	0.00	0.00	7.37	1.87	5.15	2.98	0.00	0.00	3.22
6212	13.08	0.00	2.50	0.00	0.00	0.00	3.01	0.14	0.00	0.00	0.00	0.00	0.11	0.51	0.00	0.06	0.07	0.00	0.00	2.44
6213	2.81	0.00	0.72	14.72	0.00	0.46	1.46	1.42	0.00	0.00	0.00	0.00	0.00	6.13	0.47	0.68	4.12	2.13	0.38	2.94
6214	7.15	0.00	0.35	0.00	0.00	0.00	4.81	0.00	0.00	0.00	1.51	0.00	0.00	3.26	0.26	0.63	4.81	7.53	0.34	3.07
6215	3.86	0.80	24.16	0.00	0.00	0.00	3.57	0.00	0.00	6.76	0.00	0.00	0.00	14.52	0.51	3.38	1.11	21.02	(0.15)	7.23
6231	0.00	0.16	0.00	0.35	0.00	8.02	4.08	3.76	0.00	7.29	0.00	0.00	0.00	3.73	0.02	41.18	(1.68)	13.98	0.00	7.41
6232	0.00	0.00	0.00	1.27	32.07	5.30	6.11	27.30	0.00	9.13	0.00	0.00	0.19	2.04	2.35	4.27	3.27	5.34	1.37	7.69
6236	0.00	0.00	0.00	0.00	0.00	2.40	0.00	0.00	0.00	1.68	0.00	0.12	0.00	0.00	0.37	0.63	1.67	0.00	0.00	1.14
6237	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	2.13	0.00	3.83	0.00	0.00	0.75	2.18	0.00	0.00	0.00	1.87
6238	10.37	0.00	0.00	0.00	15.40	1.80	0.35	0.00	0.00	2.29	0.00	0.00	0.00	4.15	0.90	1.08	5.64	0.44	0.00	4.24
6241	0.45	8.42	16.07	0.00	6.81	3.02	9.50	16.79	0.00	1.72	0.00	3.44	1.84	2.57	4.62	21.49	5.34	20.81	5.58	8.10
6242	5.86	0.00	3.71	0.00	3.80	16.22	11.96	0.13	0.00	3.87	0.00	0.00	0.78	4.42	25.47	5.95	18.25	21.30	1.45	8.21
6243	0.00	0.00	26.20	5.18	1.00	7.56	2.33	0.00	0.00	0.86	0.00	5.38	6.44	5.26	0.00	25.84	3.57	0.00	0.00	6.33
6244	2.54	3.02	15.74	4.11	5.25	2.11	11.43	2.06	4.18	3.50	0.00	4.06	3.07	5.09	8.44	13.48	2.64	13.74	1.38	5.86
6245	0.00	0.00	31.36	0.00	0.00	0.00	1.53	0.39	0.00	3.55	0.00	0.00	0.00	0.00	0.00	6.48	0.00	10.41	0.00	8.95
6246	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.98
6247	4.81	0.00	6.44	0.00	0.00	8.40	2.64	0.00	0.00	2.16	0.00	0.00	0.00	3.12	9.66	0.00	1.33	21.26	0.00	6.65
6248	0.00	0.00	12.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	8.55
6255	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06	0.00	0.00	0.00	0.62
6272	0.00	0.00	10.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.14
6273	0.00	0.00	0.00	0.00	0.00	0.00	8.82	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.82
6312	0.00	3.74	0.00	0.00	1.43	0.00	4.07	2.84	0.00	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	0.44	0.00	2.71
6313	0.00	0.00	1.07	0.00	0.00	2.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.47	0.00	1.56	0.00	0.00	0.00	1.98
Average(a)	5.25	5.15	9.55	8.64	10.08	7.82	4.61	7.70	5.47	5.56	9.36	5.18	5.94	6.00	5.99	7.43	5.67	7.03	7.06	

(a) Zero implies no data and not included in average

Table 3.7. Summary of Energy-Savings Potential (%)

DIECO	Industry SIC Number																			Average(s)
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
3121	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.08	0.00	0.13	0.00	0.06
3141	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.06
3211	0.28	0.28	1.85	0.26	0.37	0.76	0.42	0.34	0.31	0.37	0.56	0.34	0.17	0.79	0.39	0.30	0.17	0.37	0.45	0.47
3213	0.20	0.01	0.03	0.00	0.00	0.08	0.36	0.26	0.00	0.16	0.00	0.10	0.36	0.24	0.17	0.58	0.34	0.03	0.00	0.21
3221	0.32	0.47	0.18	0.27	1.88	0.54	0.42	0.52	0.19	0.49	0.51	0.52	0.63	0.67	1.08	0.45	0.35	0.24	0.22	0.52
3231	0.78	0.88	2.88	6.16	6.76	2.15	0.94	1.35	2.00	2.78	2.88	3.04	3.38	6.32	3.45	2.03	3.51	1.40	5.48	3.04
3232	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03
3243	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.00	0.04	0.08	0.02	0.00	0.00	0.12	0.00	0.00	0.07	0.00	0.04
3311	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
3312	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.06
3342	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.04
3351	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.08	0.00	0.00	0.02
3352	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4111	0.10	0.00	0.06	0.02	0.49	0.08	0.27	0.88	0.00	0.28	0.23	0.20	0.52	0.11	0.11	0.26	0.41	0.11	0.00	0.28
4112	0.07	0.33	0.27	0.81	2.40	0.73	0.44	0.85	0.00	2.34	0.48	3.18	0.44	0.57	0.88	0.56	0.32	0.61	1.38	0.82
4113	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.04
4115	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
4121	0.12	0.04	0.33	0.00	0.24	0.05	0.34	0.41	0.00	0.11	0.00	0.58	0.08	0.44	0.30	0.24	0.12	0.00	0.00	0.24
4122	0.00	0.00	1.01	0.13	0.08	0.18	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.04	0.04	0.03	0.00	0.00	0.06	0.24
4125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.03
4131	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.54	0.11	0.00	0.00	0.55	0.00	0.00	0.21
4132	0.00	0.00	0.01	0.00	0.00	0.08	0.00	0.03	0.00	0.04	1.03	0.00	0.00	0.01	0.01	0.13	0.00	0.00	0.00	0.17
4141	0.01	0.00	0.00	0.34	0.00	0.06	0.00	0.00	0.85	0.25	0.00	0.00	0.00	0.16	0.02	0.22	0.08	0.00	0.00	0.12
4142	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01
4222	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.02
4312	0.00	0.00	0.08	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
4321	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
5121	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.12	0.05	0.00	0.00	0.07
5122	1.20	0.57	0.35	1.37	0.88	2.41	0.88	1.10	1.78	0.84	2.71	1.30	1.58	1.12	1.04	0.50	0.27	0.32	0.25	1.08
5123	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.00	0.00	0.00	0.21	0.07
5213	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5214	0.00	0.00	0.00	0.57	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.02	0.13	0.00	0.00	0.01	0.00	0.15
5218	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.08
5221	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5222	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.03	0.06	0.00	0.00	0.00	0.08
5224	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
5311	0.00	0.08	0.08	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.07	0.28	0.10
5331	0.06	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
5333	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.07
5335	0.20	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.08

Table 3.7. (contd)

DIECO	Industry SIC Number																			Average total
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
5336	1.36	0.04	0.00	0.00	0.00	0.00	0.28	0.43	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.36
5338	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
5339	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
5341	0.01	0.00	0.23	0.19	0.08	0.05	0.29	0.03	0.04	0.03	0.00	0.04	0.05	0.08	0.13	0.17	0.05	0.12	0.27	0.11
5355	1.51	1.21	0.40	1.97	0.99	1.42	1.61	0.86	2.36	0.65	1.12	1.00	1.15	0.91	0.51	0.52	0.74	0.38	0.39	1.04
5511	0.28	0.21	0.47	0.05	0.63	0.34	0.38	0.70	0.00	2.80	1.00	0.29	0.44	0.28	0.80	1.46	0.20	0.94	0.83	0.65
5512	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.01	0.00	0.00	0.02	0.11	0.00	0.00	0.00	0.17
5514	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.08	0.03	0.32	0.00	0.22	0.00	0.16
5521	0.00	0.00	0.00	0.98	0.72	0.47	0.03	0.11	0.00	0.01	0.00	0.00	0.04	0.00	0.08	0.10	0.23	0.01	0.00	0.23
5525	0.01	0.07	0.14	0.00	0.00	0.00	0.06	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
6111	0.38	0.72	3.61	0.58	1.88	0.82	0.82	0.44	0.00	0.43	2.04	0.46	0.20	1.12	1.10	2.15	2.85	3.06	2.77	1.38
6112	0.01	0.02	0.50	0.36	0.04	0.21	0.29	0.14	0.04	0.38	1.86	0.11	0.38	0.45	0.38	0.24	1.83	0.00	1.18	0.46
6114	0.00	0.04	0.08	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.00	0.01	0.01	0.00	0.03
6121	0.80	0.71	2.92	0.88	0.35	0.88	0.19	0.54	0.84	0.85	5.97	0.14	0.45	0.73	0.52	0.52	0.58	0.43	0.46	0.95
6122	0.23	0.07	0.53	0.06	0.28	0.17	0.34	0.17	0.00	0.10	0.88	0.00	0.03	0.12	0.19	0.37	0.68	0.53	0.10	0.27
6125	0.27	0.41	0.42	0.06	0.51	0.54	0.08	0.18	0.00	0.11	1.55	0.03	0.13	0.02	0.74	0.42	0.58	0.21	0.84	0.39
6126	0.03	0.00	0.03	0.11	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.04	0.01	0.08	0.04	0.02	0.03	0.01	0.00	0.03
6211	0.02	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.01	0.04	0.11	0.00	0.00	0.03
6212	0.08	0.00	0.03	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
6213	0.01	0.00	0.02	0.14	0.00	0.00	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.05	0.08	0.01	0.03
6214	0.12	0.00	0.01	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.12	0.00	0.00	0.02	0.00	0.03	0.12	0.11	0.02	0.06
6215	0.08	0.01	0.51	0.00	0.00	0.00	0.22	0.00	0.00	0.08	0.00	0.00	0.00	0.08	0.01	0.05	0.01	0.32	0.00	0.12
6231	0.00	0.00	0.00	0.00	0.00	0.14	0.11	0.07	0.00	0.13	0.00	0.00	0.00	0.01	0.00	1.75	0.04	0.62	0.00	0.25
6232	0.00	0.00	0.00	0.01	0.51	0.24	0.37	0.26	0.00	0.27	0.00	0.00	0.00	0.04	0.10	0.24	0.04	0.24	0.07	0.18
6236	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01
6237	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02
6238	0.03	0.00	0.00	0.00	0.24	0.01	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.06	0.01	0.02	0.07	0.01	0.00	0.05
6241	0.01	0.20	0.51	0.00	0.22	0.14	0.82	0.48	0.00	0.04	0.00	0.08	0.04	0.07	0.13	0.91	0.40	0.95	0.14	0.33
6242	0.10	0.00	0.08	0.00	0.08	0.25	0.32	0.00	0.00	0.05	0.00	0.00	0.01	0.10	0.21	0.08	0.46	0.86	0.04	0.16
6243	0.00	0.00	0.30	0.05	0.02	0.11	0.04	0.00	0.00	0.00	0.00	0.06	0.04	0.10	0.00	0.18	0.08	0.00	0.00	0.08
6244	0.29	0.11	2.32	0.41	0.33	0.24	2.91	0.25	0.88	0.44	0.00	0.38	0.17	0.48	1.14	1.91	0.40	1.87	0.17	0.81
6245	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.18	0.00	0.10
6246	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6247	0.02	0.00	0.07	0.00	0.00	0.18	0.12	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.18	0.00	0.03	0.32	0.00	0.10
6248	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.14
6255	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01
6272	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
6273	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
6312	0.00	0.03	0.00	0.00	0.02	0.00	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.01	0.00	0.03
6313	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.02
Total	9.06	6.33	21.58	15.31	19.82	13.53	13.95	10.51	9.75	15.08	22.63	12.36	10.96	15.83	14.12	17.53	15.88	14.48	15.58	

(a) Zero implies no data and not included in average

Table 3.8. Average DIECO Implementation Cost (\$/kWh)

DIECO	Industry SIC Number																			Average
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
3121	n/a	n/a	n/a	n/a	n/a	n/a	0.024	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.021	0.120	n/a	n/a	n/a	0.065
3141	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.078	n/a	n/a	n/a	0.144	n/a	n/a	n/a	n/a	n/a	0.111
3211	0.011	0.007	0.018	0.027	0.001	0.015	0.021	0.000	0.008	0.011	n/a	0.012	0.001	0.023	0.023	0.025	0.080	0.008	n/a	0.017
3213	0.025	0.028	n/a	n/a	n/a	0.022	0.047	0.001	n/a	0.025	n/a	0.005	0.087	0.023	0.108	0.078	0.058	n/a	n/a	0.041
3221	0.058	0.080	0.088	0.035	0.082	0.082	0.077	0.085	0.089	0.057	0.234	0.055	0.082	0.053	0.082	0.088	0.073	0.080	0.041	0.078
3231	0.018	0.024	0.013	0.023	0.018	0.015	0.015	0.017	0.018	0.018	0.008	0.023	0.018	0.014	0.018	0.012	0.018	0.023	0.008	0.017
3232	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.057	n/a	n/a	n/a	n/a	0.057
3243	n/a	n/a	0.088	n/a	n/a	n/a	n/a	n/a	n/a	0.014	0.084	0.001	0.015	n/a	0.003	n/a	n/a	0.101	n/a	0.042
3311	0.123	n/a	n/a	n/a	n/a	n/a	0.007	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.085
3312	n/a	n/a	n/a	n/a	n/a	n/a	0.047	n/a	n/a	0.174	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.418
3342	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.031	n/a	n/a	n/a	n/a	0.031
3351	0.104	n/a	0.085	n/a	n/a	n/a	n/a	n/a	n/a	0.017	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.082
3352	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.053	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.053
4111	0.007	n/a	0.017	n/a	0.044	0.038	0.020	0.020	n/a	0.004	0.050	n/a	0.008	n/a	0.028	0.018	0.024	0.024	n/a	0.022
4112	0.010	0.035	0.032	0.005	0.064	n/a	0.019	0.045	n/a	0.032	0.050	0.043	0.043	0.027	0.018	0.021	0.008	0.038	0.033	0.028
4113	n/a	n/a	n/a	n/a	n/a	n/a	0.080	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.080
4115	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.084	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.084
4121	0.010	n/a	0.288	n/a	n/a	n/a	0.014	0.028	n/a	0.053	n/a	n/a	0.003	0.083	0.008	0.005	0.003	n/a	n/a	0.048
4122	n/a	n/a	n/a	n/a	n/a	0.058	n/a	n/a	n/a	0.018	n/a	n/a	n/a	n/a	0.028	0.448	n/a	n/a	n/a	0.135
4125	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.102	n/a	n/a	n/a	n/a	0.102
4131	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.037	n/a	n/a	n/a	0.220	n/a	n/a	0.128
4132	n/a	n/a	0.148	n/a	n/a	0.048	n/a	n/a	n/a	0.022	0.037	n/a	n/a	0.021	0.154	0.007	n/a	n/a	n/a	0.057
4141	n/a	n/a	0.088	n/a	n/a	n/a	0.080	n/a	0.008	0.028	n/a	n/a	n/a	0.073	0.031	n/a	0.003	n/a	n/a	0.088
4142	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.088
4222	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.084	n/a	n/a	n/a	n/a	n/a	0.084
4312	n/a	n/a	2.950	n/a	n/a	0.073	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.512
4321	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5121	n/a	0.007	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.033	n/a	n/a	n/a	0.001	0.283	n/a	n/a	0.094
5122	0.015	0.004	n/a	0.003	n/a	0.083	0.023	0.058	n/a	0.032	n/a	0.008	0.008	0.020	0.015	0.008	n/a	0.018	0.040	0.023
5123	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.072	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.072
5213	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5214	n/a	n/a	n/a	0.071	n/a	0.021	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.008	n/a	0.043
5218	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.032	n/a	n/a	n/a	0.032
5221	0.078	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.078
5222	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.220	n/a	n/a	n/a	n/a	n/a	0.015	n/a	n/a	n/a	0.117
5224	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.032	n/a	n/a	n/a	0.032
5311	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.003	n/a	n/a	n/a	0.178	n/a	0.001
5331	0.050	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.025
5333	0.035	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.108	0.081	n/a	0.088
5335	0.012	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.004	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.030	n/a	0.015

Table 3.8. (contd)

DIECO	Industry SIC Number																		Average
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	
5336	0.017	n/a	n/a	n/a	n/a	n/a	0.122	0.079	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.073
5339	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5339	n/a	n/a	n/a	n/a	n/a	n/a	0.013	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.013
5341	n/a	n/a	n/a	0.008	n/a	0.008	n/a	n/a	n/a	0.024	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.034
5356	0.032	0.041	0.018	0.024	0.023	0.024	0.041	0.015	0.045	0.013	n/a	0.034	0.023	0.047	0.038	0.023	0.017	0.062	0.007
5611	0.067	0.068	0.018	0.025	0.007	0.047	0.038	0.108	n/a	0.052	0.105	0.042	0.044	0.053	0.041	0.036	0.037	0.035	0.082
5612	n/a	n/a	0.031	n/a	n/a	n/a	n/a	n/a	n/a	0.038	n/a	n/a	n/a	n/a	n/a	0.017	n/a	n/a	n/a
5614	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.028	0.024	0.014	n/a	0.012	n/a
5621	n/a	n/a	n/a	0.087	0.083	0.229	0.118	0.008	n/a	n/a	n/a	n/a	0.002	0.084	0.000	0.377	0.085	0.022	n/a
5626	0.080	0.025	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.013	n/a	n/a	n/a	0.033
6111	0.018	0.004	0.020	n/a	0.008	0.006	0.042	0.028	n/a	0.010	0.040	0.027	0.002	0.017	0.036	0.033	0.047	0.036	0.024
6112	0.080	n/a	n/a	0.003	n/a	0.004	0.128	0.177	n/a	0.028	n/a	0.041	0.118	0.075	0.080	0.248	0.100	n/a	0.087
6114	n/a	0.011	0.182	n/a	0.142	n/a	n/a	n/a	n/a	0.083	n/a	n/a	n/a	0.033	0.056	n/a	n/a	0.114	n/a
6121	0.015	0.012	0.021	0.031	0.001	0.010	0.058	0.037	0.023	0.023	n/a	0.010	0.017	0.010	0.008	0.048	n/a	0.008	0.028
6122	0.074	0.012	n/a	0.008	0.034	0.031	0.048	0.014	n/a	0.045	0.010	n/a	0.065	0.081	0.033	0.038	0.027	n/a	0.040
6126	n/a	0.083	0.138	n/a	n/a	n/a	n/a	n/a	n/a	0.081	0.003	0.138	0.088	0.231	0.171	n/a	0.077	n/a	0.143
6128	n/a	0.223	n/a	0.012	n/a	n/a	n/a	0.012	n/a	0.056	n/a	0.036	n/a	0.038	0.021	0.047	0.014	0.082	n/a
6211	0.031	n/a	0.033	n/a	n/a	n/a	n/a	n/a	n/a	0.053	n/a	n/a	n/a	0.018	n/a	0.032	n/a	n/a	0.032
6212	0.008	n/a	0.128	n/a	n/a	n/a	0.018	0.118	n/a	n/a	n/a	n/a	n/a	0.012	n/a	0.027	0.020	n/a	0.047
6213	0.037	n/a	0.017	0.088	n/a	0.072	0.012	0.027	n/a	n/a	n/a	n/a	n/a	0.003	0.042	0.047	0.154	0.074	0.080
6214	0.030	n/a	0.088	n/a	n/a	n/a	0.171	n/a	n/a	n/a	0.027	n/a	n/a	0.042	0.148	0.087	0.007	0.017	0.027
6215	0.048	0.102	n/a	n/a	n/a	n/a	0.108	n/a	n/a	0.018	n/a	n/a	n/a	0.072	0.078	0.075	0.022	0.077	n/a
6231	n/a	n/a	n/a	n/a	n/a	n/a	0.038	0.028	n/a	0.028	n/a	n/a	n/a	0.008	0.080	0.023	n/a	0.018	0.032
6232	n/a	n/a	n/a	n/a	0.002	0.050	0.042	n/a	n/a	0.042	n/a	n/a	n/a	0.008	0.087	0.023	0.018	0.025	n/a
6238	n/a	n/a	n/a	n/a	n/a	0.011	n/a	n/a	n/a	0.020	n/a	n/a	n/a	n/a	n/a	0.074	0.083	n/a	0.048
6237	n/a	n/a	0.038	n/a	n/a	n/a	n/a	n/a	n/a	0.008	n/a	0.071	n/a	n/a	0.078	0.020	n/a	n/a	0.043
6238	n/a	n/a	n/a	n/a	n/a	n/a	0.018	n/a	n/a	0.004	n/a	n/a	n/a	0.008	n/a	0.014	0.020	n/a	0.013
6241	0.000	0.002	n/a	n/a	0.025	0.003	0.004	0.022	n/a	0.048	n/a	n/a	n/a	0.000	0.001	0.062	0.018	n/a	0.002
6242	0.313	n/a	0.024	n/a	n/a	n/a	n/a	n/a	n/a	0.212	n/a	n/a	0.188	0.088	n/a	0.013	0.033	n/a	0.118
6243	n/a	n/a	n/a	0.088	0.003	0.004	0.007	n/a	n/a	n/a	n/a	0.024	0.018	0.008	n/a	n/a	n/a	n/a	0.018
6244	0.038	0.055	0.061	0.058	0.008	0.031	0.058	0.042	0.010	0.078	n/a	0.015	0.021	0.027	0.044	0.038	0.017	0.044	0.038
6245	n/a	n/a	0.082	n/a	n/a	n/a	0.074	0.047	n/a	0.188	n/a	n/a	n/a	n/a	n/a	0.034	n/a	0.211	n/a
6246	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6247	0.145	n/a	0.083	n/a	n/a	0.022	0.023	n/a	n/a	0.018	n/a	n/a	n/a	0.088	0.037	n/a	0.078	n/a	0.058
6248	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.230	n/a	n/a	n/a	n/a	0.230
6255	n/a	n/a	0.382	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.208	n/a	n/a	0.300
6272	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.000
6273	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6312	n/a	0.005	n/a	n/a	n/a	n/a	0.051	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.183	n/a
6313	n/a	n/a	n/a	n/a	n/a	0.108	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.088	n/a	n/a	0.088
Average	0.051	0.040	0.185	0.038	0.031	0.048	0.082	0.048	0.030	0.060	0.067	0.034	0.033	0.047	0.050	0.080	0.058	0.057	0.038

n/a - not available, no implementation data contained in the database

Table 3.9. National Industrial O&M Energy-Savings Potential (million kWh/yr)

DIECO	Industry SIC Number																			Total
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
3121	1.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	25.6	3.6	30.6	0.0	19.7	0.0	64.9
3141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0	0.0	0.0	33.2	0.0	0.0	1.8	0.0	0.0	51.6
3211	164.6	80.3	109.3	55.0	22.3	636.6	77.3	564.6	136.2	134.2	5.0	109.6	264.7	253.7	137.2	99.1	62.7	53.7	22.6	3,213.3
3213	112.3	2.8	1.9	0.0	0.0	91.4	65.7	442.8	0.0	55.9	0.0	33.7	542.5	76.2	61.6	169.1	124.7	4.5	0.0	1,805.2
3221	164.4	134.0	9.9	56.1	113.4	602.1	76.6	895.2	86.9	177.4	4.6	167.6	957.2	215.6	366.7	146.8	129.2	35.3	11.4	4,390.9
3231	446.6	186.1	150.4	1,288.3	412.3	2,362.2	171.1	2,299.3	896.1	1,001.6	25.9	960.7	5,156.7	2,039.6	1,226.5	666.6	1,293.0	206.1	279.2	21,114.7
3232	0.0	0.0	0.0	0.0	0.0	77.9	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	61.9
3243	0.0	0.0	1.0	0.0	0.0	0.0	0.7	41.3	0.0	13.5	0.8	7.9	0.8	1.4	42.6	0.0	0.0	10.7	0.0	126.5
3311	19.4	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	23.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.3
3312	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	18.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.6
3342	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	27.3	0.0	0.0	0.0	0.0	29.8
3351	1.1	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	5.4	0.0	30.1	0.0	0.0	41.5
3352	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7
4111	55.3	0.0	3.5	4.2	30.0	69.2	49.6	1,501.1	0.0	102.4	2.1	65.3	764.5	36.0	37.6	65.2	151.5	15.9	0.0	3,013.7
4112	40.4	94.5	15.0	166.6	146.5	606.3	60.7	1,114.7	0.0	641.6	4.4	1,027.9	666.7	162.5	316.3	160.3	117.1	66.3	70.6	5,875.6
4113	2.1	0.0	0.0	0.0	0.0	1.6	2.1	0.0	0.0	0.0	0.0	2.4	267.5	0.0	0.0	0.0	0.0	0.0	0.0	275.7
4115	0.0	0.0	0.0	0.0	0.0	64.6	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	69.0
4121	70.8	12.5	16.4	0.0	14.6	52.6	62.9	696.2	0.0	39.5	0.0	180.6	130.7	142.6	105.1	76.4	45.8	0.0	0.0	1,661.3
4122	0.0	0.0	56.6	26.5	5.7	214.6	0.0	0.0	0.0	192.5	0.0	0.0	0.0	14.4	12.6	10.7	0.0	0.0	2.4	536.2
4125	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.1	2.2	0.0	0.0	0.0	22.3
4131	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	8.9	0.0	0.0	519.8	35.7	0.0	0.0	202.4	0.0	0.0	768.5
4132	0.0	0.0	0.6	0.0	0.0	63.6	0.0	56.7	0.0	14.2	9.3	0.0	0.0	4.1	3.8	42.8	0.0	0.0	0.0	216.9
4141	6.1	0.0	0.2	7.4	0.0	51.2	0.1	0.0	291.0	91.5	0.0	0.0	0.0	51.6	7.3	71.1	23.6	0.4	0.0	600.9
4142	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	4.8
4222	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.0	5.9
4312	0.0	0.0	4.4	0.0	0.0	76.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.3
4321	0.0	0.0	0.0	0.0	0.0	146.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	146.6
5121	0.0	8.8	1.9	0.0	0.0	0.0	0.0	180.5	0.0	6.6	0.0	56.1	0.0	0.0	0.0	36.3	19.5	0.0	0.0	266.9
5122	665.6	163.1	19.5	266.2	40.3	2,667.6	156.3	1,662.8	766.1	302.9	24.4	420.6	2,376.5	361.3	370.2	163.5	96.6	46.5	12.5	10,673.9
5123	0.0	0.0	0.0	9.8	0.0	0.0	0.0	0.0	0.0	1.7	0.0	16.5	0.0	16.4	0.0	0.0	0.0	0.0	10.6	55.0
5213	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4
5214	0.0	0.0	0.0	119.8	0.0	36.6	0.0	0.0	0.0	0.0	0.0	36.5	0.0	7.9	45.8	0.0	0.0	1.1	0.0	247.6
5216	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.5	0.0	0.0	0.0	61.1
5221	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4
5222	0.0	0.0	0.0	0.0	0.0	0.0	11.3	0.0	0.0	66.7	0.0	0.0	0.0	3.6	10.2	19.9	0.0	0.0	0.0	134.9
5224	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	2.9
5311	0.0	22.4	4.5	0.0	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	10.7	0.0	10.3	14.7	76.3
5331	33.7	0.0	0.0	0.0	0.0	0.0	5.5	3.7	213.4	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	257.6
5333	107.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	1.0	0.0	114.7
5335	113.1	0.0	0.0	0.0	0.0	0.0	7.2	0.0	0.0	32.9	0.0	0.0	0.0	0.7	0.0	0.0	9.0	14.9	0.0	166.7
5336	776.9	12.0	0.0	0.0	0.0	0.0	51.7	727.2	0.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,566.9
5338	31.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.6
5339	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9
5341	4.7	0.0	12.7	40.4	5.3	59.1	53.6	55.6	15.7	10.6	0.0	12.1	69.3	25.2	46.4	57.3	16.9	17.5	13.5	516.4
5355	663.6	342.4	22.5	411.5	60.3	1,574.6	295.1	1,470.4	1,056.7	233.7	10.0	323.0	1,742.6	293.6	180.7	170.6	270.5	95.6	19.6	6,366.1

Table 3.9. (contd)

DECO	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	Total
5511	102.8	59.8	26.2	11.5	36.2	316.0	70.9	1,193.6	0.0	935.8	9.0	94.2	672.0	84.8	215.1	476.6	72.5	136.7	42.3	4,081.6
5512	0.0	0.0	36.5	0.0	0.0	0.0	0.0	0.0	0.0	56.4	0.0	4.8	4.5	0.0	5.4	36.8	0.0	0.0	0.0	148.5
5514	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	204.3	27.4	9.2	105.8	0.0	32.6	0.0	378.4
5521	0.0	0.0	0.0	204.2	43.6	524.4	6.3	192.6	0.0	4.2	0.0	0.0	53.3	0.5	21.6	32.2	83.1	1.3	0.0	1,197.7
5525	3.9	20.0	7.8	0.0	0.0	0.0	10.1	0.0	0.0	8.6	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	51.6
8111	214.9	205.3	202.3	110.3	102.4	690.6	114.0	756.5	0.0	154.2	16.3	148.0	310.6	361.1	382.1	704.1	1,048.5	450.0	141.3	8,311.4
8112	4.3	4.7	27.6	75.6	2.5	234.7	53.2	239.5	168	136.6	14.9	36.8	506.7	146.5	133.6	79.4	708.6	0.0	58.9	2,567.1
8114	0.0	11.5	4.6	0.0	5.2	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	1.8	23.9	1.6	4.5	1.5	0.0	56.3
8121	344.7	200.5	157.7	141.5	21.5	951.0	34.5	922.8	419.5	233.4	53.7	46.5	684.5	236.6	165.2	199.0	212.4	63.3	23.5	5,102.0
8122	129.2	18.0	29.5	13.5	17.8	191.7	81.6	269.4	0.0	35.8	6.2	0.0	52.6	36.8	68.1	122.8	244.5	77.5	5.0	1,404.2
8125	153.6	117.0	23.5	11.3	31.4	600.6	10.2	311.1	0.0	36.3	14.0	9.7	197.7	8.5	265.1	136.8	217.1	30.8	43.0	2,217.7
8126	17.0	1.1	1.7	24.0	0.0	1.2	0.0	119.1	0.0	0.6	0.0	12.5	15.6	28.6	14.8	7.6	11.2	0.8	0.0	255.8
8211	14.0	0.0	2.0	0.0	0.0	0.0	0.2	0.0	0.0	5.2	0.0	0.0	0.0	7.8	2.7	12.0	41.1	0.0	0.0	66.0
8212	49.0	0.0	1.5	0.0	0.0	0.0	14.5	2.3	0.0	0.0	0.0	0.0	1.2	1.1	0.0	0.1	0.3	0.0	0.0	70.0
8213	4.8	0.0	0.8	26.2	0.0	3.8	7.0	46.2	0.0	0.0	0.0	0.0	0.0	12.8	0.7	3.2	18.0	9.5	0.5	136.7
8214	66.8	0.0	0.4	0.0	0.0	0.0	36.6	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.4	8.7	44.3	18.6	0.6	164.9
8215	43.4	3.2	28.5	0.0	0.0	0.0	40.1	0.0	0.0	20.8	0.0	0.0	0.0	30.6	4.4	15.7	5.1	48.8	60.2	238.5
8231	0.0	0.3	0.0	0.7	0.0	151.6	19.7	122.4	0.0	45.1	0.0	0.0	0.0	3.8	0.0	574.8	(15.5)	91.2	0.0	994.1
8232	0.0	0.0	0.0	2.4	31.1	287.4	66.6	444.2	0.0	86.6	0.0	0.0	1.8	12.8	34.1	79.6	15.0	36.7	3.4	1,095.1
8236	0.0	0.0	0.0	0.0	0.0	20.1	0.0	0.0	0.0	2.6	0.0	0.5	0.0	0.0	0.5	1.5	7.7	0.0	0.0	32.9
8237	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	14.5	0.0	0.0	1.1	5.1	0.0	0.0	0.0	24.3
8238	19.4	0.0	0.0	0.0	14.8	15.1	1.1	0.0	0.0	7.1	0.0	0.0	0.0	17.5	3.8	3.8	25.8	1.0	0.0	111.1
8241	3.4	56.1	28.4	0.0	13.4	182.1	187.7	819.5	0.0	16.0	0.0	26.1	57.1	21.7	47.0	300.0	147.3	138.1	8.8	2,001.8
8242	55.6	0.0	4.4	0.0	3.7	272.5	57.7	2.1	0.0	18.0	0.0	0.0	18.2	32.5	74.6	27.7	167.8	94.9	1.8	826.4
8243	0.0	0.0	16.6	9.8	1.6	127.6	7.5	0.0	0.0	1.3	0.0	20.4	66.6	33.3	0.0	60.1	32.9	0.0	0.0	378.7
8244	166.4	36.0	125.9	66.7	20.3	266.1	532.0	435.2	442.1	154.6	6.0	124.1	253.8	155.4	464.7	627.4	145.6	244.9	6.6	4,229.9
8245	0.0	0.0	16.5	0.0	0.0	0.0	2.5	0.3	0.0	11.0	0.0	0.0	0.0	0.0	0.0	30.1	6.0	23.2	0.0	81.6
8246	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	1.4
8247	9.0	0.0	3.8	0.0	0.0	211.6	21.2	0.0	0.0	3.3	0.0	0.0	0.0	0.0	56.3	0.0	12.2	47.4	0.0	368.1
8249	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5
8255	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	5.1
8272	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0
8273	0.0	0.0	0.0	0.0	0.0	0.0	14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.2
8312	0.0	7.4	0.0	0.0	1.4	0.0	0.0	42.8	0.0	0.0	0.0	0.0	0.0	0.0	9.7	0.0	0.0	1.0	0.0	75.5
8313	0.0	0.0	0.0	0.0	0.0	23.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	7.3	0.0	0.0	0.0	34.1
Total	5,169.3	1,787.0	1,268.7	3,199.7	1,208.2	15,006.6	2,552.2	17,843.8	4,367.4	5,436.1	203.7	3,992.4	16,603.5	5,113.6	5,029.1	5,750.6	9,948.6	2,136.5	764.5	102,429.8

Table 3.10. Pacific Northwest Industrial O&M Energy-Savings Potential (million kWh/yr)

DIECO	Industry SIC Number																			Total
	20	22	23	24	25	26	27	28	29	30	31	32	33(a)	34	35	36	37	38	39	
3121	0.05	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.12	0.48	0.00	0.14	0.00	1.34
3141	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.58	0.00	0.00	0.07	0.00	0.00	0.99
3211	7.48	0.14	0.89	12.18	0.15	99.04	1.85	23.11	2.88	2.88	0.00	4.00	8.77	4.25	4.50	1.80	2.52	0.40	0.58	175.13
3213	5.09	0.00	0.01	0.00	0.00	10.79	1.58	17.50	0.00	1.24	0.00	1.23	13.87	1.28	2.02	3.08	5.01	0.03	0.00	82.73
3221	8.38	0.24	0.08	12.42	0.79	71.11	1.84	35.39	1.82	3.94	0.00	8.12	24.48	3.82	12.89	2.38	5.18	0.28	0.29	190.97
3231	20.35	0.33	0.85	265.30	2.98	281.35	4.11	90.80	18.73	22.23	0.00	35.74	131.81	34.19	40.25	10.79	51.92	1.52	7.08	1,040.46
3232	0.00	0.00	0.00	0.00	0.00	9.20	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	9.32
3243	0.00	0.00	0.01	0.00	0.00	0.00	0.02	1.83	0.00	0.30	0.00	0.29	0.01	0.02	1.40	0.00	0.00	0.08	0.00	3.78
3311	6.88	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.41
3312	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58
3342	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.95
3351	6.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.18	0.00	1.21	0.00	0.00	1.54
3352	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
4111	2.51	0.00	0.02	0.82	0.21	10.54	1.20	58.34	0.00	2.27	0.00	2.38	20.08	0.80	1.24	1.38	8.08	0.12	0.00	108.87
4112	1.83	0.17	0.08	37.38	1.02	85.48	1.84	44.07	0.00	18.88	0.00	37.48	17.05	3.08	10.38	3.08	4.70	0.88	1.78	278.81
4113	0.08	0.00	0.00	0.00	0.00	0.18	0.05	0.00	0.00	0.00	0.00	0.08	8.84	0.00	0.00	0.00	0.00	0.00	0.00	7.28
4115	0.00	0.00	0.00	0.00	0.00	7.83	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.73
4121	3.21	0.02	0.12	0.00	0.10	8.24	1.51	27.52	0.00	0.88	0.00	8.85	3.34	2.38	3.45	1.27	1.84	0.00	0.00	58.84
4122	0.00	0.00	0.38	5.88	0.04	25.37	0.00	0.00	0.00	4.27	0.00	0.00	0.00	0.24	0.41	0.17	0.00	0.00	0.08	38.78
4125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.04	0.00	0.00	0.00	0.88
4131	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.20	0.00	0.00	13.29	0.80	0.00	0.00	8.13	0.00	0.00	22.55
4132	0.00	0.00	0.00	0.00	0.00	8.88	0.00	2.32	0.00	0.32	0.00	0.00	0.00	0.07	0.12	0.88	0.00	0.00	0.00	13.38
4141	0.27	0.00	0.00	1.83	0.00	8.05	0.00	0.00	8.01	2.03	0.00	0.00	0.00	0.88	0.24	1.15	0.88	0.00	0.00	19.27
4142	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.13
4222	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10
4312	0.00	0.00	0.03	0.00	0.00	8.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.35
4321	0.00	0.00	0.00	0.00	0.00	17.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.34
5121	0.00	0.02	0.01	0.00	0.00	0.00	0.00	8.34	0.00	0.02	0.00	2.12	0.00	0.00	0.00	0.84	0.78	0.00	0.00	9.83
5122	31.10	0.29	0.12	63.38	0.28	315.05	3.80	74.44	18.48	8.74	0.00	15.33	80.82	8.08	12.15	2.85	4.01	0.34	0.32	613.34
5123	0.00	0.00	0.00	2.18	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.80	0.00	0.27	0.00	0.00	0.00	0.00	0.27	3.38
5213	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
5214	0.00	0.00	0.00	28.53	0.00	4.35	0.00	0.00	0.00	0.00	0.00	1.33	0.00	0.13	1.50	0.00	0.00	0.01	0.00	33.85
5218	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	2.98
5221	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
5222	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	1.98	0.00	0.00	0.00	0.08	0.33	0.32	0.00	0.00	0.00	2.88
5224	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.05
5311	0.00	0.04	0.03	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.17	0.00	0.08	0.37	0.82
5331	1.53	0.00	0.00	0.00	0.00	0.00	0.13	0.15	4.48	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.30
5333	4.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.01	0.00	5.13
5335	5.13	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.73	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.11	0.00	8.15
5338	35.24	0.02	0.00	0.00	0.00	0.00	1.24	28.75	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	65.88
5338	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.43
5339	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
5341	0.21	0.00	0.08	8.95	0.04	8.98	1.28	2.20	0.33	0.24	0.00	0.44	1.77	0.42	1.52	0.83	0.78	0.13	0.34	28.83
5355	38.18	0.81	0.14	81.14	0.42	185.98	7.08	58.13	22.12	5.18	0.00	11.77	44.58	4.82	5.93	2.75	10.88	0.41	0.50	481.88

Table 3.10. (contd)

DIECO	Industry SIC Number																			Total
	20	22	23	24	25	26	27	28	29	30	31	32	33(a)	34	35	36	37	38	39	
5511	7.38	0.11	0.18	2.54	0.28	44.40	1.70	47.19	0.00	20.77	0.00	3.43	17.18	1.42	7.08	7.75	2.80	1.02	1.07	188.36
5512	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.00	0.17	0.11	0.00	0.18	0.80	0.00	0.00	0.00	2.58
5514	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.22	0.48	0.30	1.71	0.00	0.24	0.00	7.94
5521	0.00	0.00	0.00	45.23	0.30	81.84	0.15	7.82	0.00	0.09	0.00	0.00	1.38	0.01	0.71	0.52	3.34	0.01	0.00	121.28
5525	0.18	0.04	0.05	0.00	0.00	0.00	0.24	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.73
6111	8.75	0.38	1.27	25.78	0.71	81.58	2.73	28.80	0.00	3.42	0.00	5.43	7.84	8.05	12.87	11.40	42.10	3.32	3.57	248.18
6112	0.20	0.01	0.17	16.74	0.02	27.72	1.28	9.47	0.35	3.08	0.00	1.34	15.05	2.48	4.38	1.28	28.48	0.00	1.52	113.58
6114	0.00	0.02	0.03	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.03	0.78	0.03	0.18	0.01	0.00	1.15
6121	15.84	0.35	0.88	31.35	0.15	112.32	0.83	38.48	8.77	5.18	0.00	1.70	17.50	3.97	8.08	2.74	8.53	0.47	0.58	253.82
6122	5.88	0.03	0.18	2.88	0.12	22.84	1.48	11.44	0.00	0.78	0.00	0.00	1.34	0.85	2.27	1.88	8.82	0.57	0.13	82.31
6125	8.97	0.21	0.15	2.50	0.22	70.83	0.24	12.30	0.00	0.85	0.00	0.38	5.05	0.11	8.70	2.22	8.72	0.23	1.08	120.83
6128	0.77	0.00	0.01	5.31	0.00	0.14	0.00	4.71	0.00	0.01	0.00	0.45	0.40	0.48	0.12	0.45	0.01	0.00	0.00	13.38
6211	0.83	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.12	0.00	0.00	0.00	0.13	0.08	0.19	1.85	0.00	0.00	2.83
6212	2.22	0.00	0.01	0.00	0.00	0.00	0.35	0.08	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.01	0.00	0.00	2.73
6213	0.22	0.00	0.01	8.25	0.00	0.45	0.17	1.83	0.00	0.00	0.00	0.00	0.00	0.22	0.02	0.05	0.78	0.07	0.01	10.08
6214	3.03	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.01	0.14	1.78	0.12	0.02	8.18
6215	1.87	0.01	0.18	0.00	0.00	0.00	0.88	0.00	0.00	0.48	0.00	0.00	0.00	0.51	0.15	0.25	0.21	0.36	0.00	5.04
6231	0.00	0.00	0.00	0.15	0.00	17.80	0.47	4.84	0.00	1.00	0.00	0.00	0.00	0.07	0.00	8.30	(0.82)	0.87	0.00	33.78
6232	0.00	0.00	0.00	0.54	0.22	31.58	1.85	17.58	0.00	2.19	0.00	0.00	0.05	0.22	1.12	1.28	0.80	0.28	0.08	57.38
6238	0.00	0.00	0.00	0.00	0.00	2.38	0.00	0.00	0.00	0.08	0.00	0.02	0.00	0.00	0.02	0.02	0.31	0.00	0.00	2.80
6237	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.50	0.53	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.72
6238	0.88	0.00	0.00	0.00	0.10	1.78	0.03	0.00	0.00	0.18	0.00	0.00	0.00	0.28	0.13	0.08	1.04	0.01	0.00	4.51
6241	0.15	0.10	0.18	0.00	0.08	17.88	4.02	32.40	0.00	0.35	0.00	0.85	1.48	0.38	1.54	4.88	5.82	1.03	0.18	71.55
6242	2.50	0.00	0.03	0.00	0.03	32.18	1.38	0.08	0.00	0.40	0.00	0.00	0.41	0.55	2.43	0.45	8.74	0.70	0.05	47.92
6243	0.00	0.00	0.10	2.20	0.01	15.00	0.18	0.00	0.00	0.03	0.00	0.74	1.70	0.58	0.00	0.97	1.32	0.00	0.00	22.82
6244	7.55	0.05	0.82	18.20	0.14	31.43	12.77	17.20	8.24	3.48	0.00	4.52	8.48	2.80	13.28	10.15	5.85	1.80	6.22	148.78
6245	0.00	0.00	0.12	0.00	0.00	0.00	0.08	0.25	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.17	0.00	1.33
6246	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.05
6247	0.41	0.00	0.02	0.00	0.00	24.88	0.51	0.00	0.00	0.07	0.00	0.00	0.00	0.05	1.85	0.00	0.48	0.35	0.00	28.75
6248	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.18
6255	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.08
6272	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
6273	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
6312	0.00	0.01	0.00	0.00	0.01	0.00	0.31	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.01	0.00	2.38
6313	0.00	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.12	0.00	0.00	0.00	2.88
Total	235.37	3.18	7.80	708.81	8.38	1,772.31	81.24	708.38	81.27	120.51	0.00	145.48	428.08	85.72	185.00	83.08	234.84	15.71	20.08	4,803.81

(a) Does not include the primary aluminum industry (SIC 3334)

Table 3.11. Pacific Northwest Industrial O&M Energy-Savings Potential by Equipment End-Use Category

DIECO	DIECO Description	PNW Potential (million kWh/yr)	DIECO Frequency (%)	Average Savings (% of Plant)	Impl. Cost (\$/kWh)
<u>Air Compressors and Compressed Air Systems:</u>					
3231	Eliminate leaks in lines and valves carrying compressed air or other gases	1,040.48	30.71	8.19	0.0189
3221	Install compressor air intake in coolest location	190.87	27.55	1.82	0.0779
3211	Reduce the pressure of compressed air system to the minimum required	175.13	11.11	4.35	0.0170
3213	Reduce use of compressed air to minimum/use smaller compressor	62.73	2.87	6.10	0.0407
3232	Remove or close off unneeded compressed air lines to eliminate leaks	8.32	0.53	4.01	0.0570
3243	Install, clean or replace compressor air filters regularly	3.76	1.78	2.57	0.0420
	sub-total	1,482.37			
<u>Motors and Motor Drive Systems:</u>					
5122	Improve lubrication practices for motor driven equipment	613.34	15.82	6.52	0.0230
5355	Use energy-efficient belts and other improved mechanisms	491.89	28.82	3.89	0.0337
4321	Upgrade or repair and maintain conveyors	17.34	0.76	17.47	n/a
4113	Turn off conveyors when not in use	7.26	0.97	3.13	0.0598
	sub-total	1,129.63			
<u>Lighting:</u>					
6121	Install timers or motion sensors on little used lights or initiate schedule	253.82	12.47	8.43	0.0209
6111	Disconnect lighting fixtures, delamp, or use lower output lamps for min. light needed	248.16	9.88	12.80	0.0233
6125	Improve reflectance of walls and ceilings/add fixture reflectors/clean fixt	120.83	3.09	17.32	0.1011
6112	Reduce lighting where natural light is available/install skylights	113.68	4.24	10.48	0.0975
6122	Rewire for light shutoff in little used areas or where daylight present	62.31	2.89	9.89	0.0398
6126	Reduce exterior lighting to minimum safe levels	13.36	1.76	1.75	0.0640
6114	Disconnect ballasts	1.15	1.31	2.80	0.0830
4222	Overlap custodial work hours with normal day hours	0.10	0.33	5.57	0.0039
	sub-total	813.09			
<u>HVAC Systems:</u>					
6244	Install or use timers or thermostats for space conditioning	146.79	12.36	5.88	0.0368
6241	Keep space temperature lower during heating season, higher during cooling	71.55	3.82	8.10	0.0147
6232	Reduce ventilation air to minimum safe levels	57.36	3.09	7.69	0.0372
6242	Minimize areas where space is conditioned/isolate cooler areas from warmer	47.82	1.83	8.21	0.1180
6231	Reduce outside air for ventilation except with economizer/recycle HVAC	33.78	1.85	7.41	0.0322
6247	Establish HVAC equipment maintenance schedules	28.75	1.80	6.65	0.0591
6243	Reduce heating/shut air conditioning manually when building is unoccupied	22.82	1.30	8.33	0.0187
6213	Seal unnecessary dampers, flues, louvers, and other wall and roof openings	10.06	1.48	2.94	0.0503
6214	Install weather stripping on loose-fitting windows and doors	6.16	2.73	3.07	0.0628
6215	Install door seals, plastic strip doors or air curtains at loading docks	5.04	2.02	7.23	0.0689
6238	Centralize control of exhaust fans to ensure shutdown or establish program	4.15	1.20	4.24	0.0128
6211	Close doors, windows and loading doors in space conditioned areas	2.83	1.29	3.22	0.0320
6236	Clean or replace air filters regularly	2.80	0.79	1.14	0.0495
6212	Repair or replace broken windows, sashes, doors etc./plug cracks	2.73	1.07	2.44	0.0487
6312	Clean or repair air conditioning refrigerant condensers	2.38	1.15	2.71	0.0731
6245	Separate controls of air handlers from controls of A/C and heating	1.33	1.11	8.95	0.1095
3342	Operate cooling towers at constant outlet temperature to avoid sub-cooling	0.95	0.62	5.50	0.0314
5525	Isolate hot/cold equipment from manufacturing areas to minimize HVAC	0.73	0.95	4.82	0.0329
6237	Replace high-resistance grilles, ducts, etc. with properly sized fittings	0.72	0.76	1.87	0.0428
6273	Modify air conditioning system to enable air compressor to operate at lower	0.34	0.88	8.82	n/a
6249	Use water sparingly on air conditioning exchanger to improve heat transfer	0.18	1.22	8.55	0.2304
6246	Close outdoor air dampers during warm-up or cool-down periods	0.05	0.41	0.88	n/a
6272	Shut steam or hot water lines to space heating units during mild weather	0.04	1.05	10.14	0.0000
	sub-total	449.44			

Table 3.11. (contd)

DIECO	DIECO Description	PNW Potential (million kWh/yr)	DIECO Frequency (%)	Average Savings (% of Plant)	Impl. Cost (\$/kWh)
<u>Equipment Scheduling and Control Systems:</u>					
4112	Reduce operating time of equipment to the minimum required/install timers	276.81	12.04	7.41	0.0290
4111	Shut down equipment when not in use or setback its temperature	108.87	3.57	8.98	0.0218
4131	Reduce temperature or power requirement of process equipment on standby	22.55	1.06	17.87	0.1284
4132	Minimize operation of equipment required to be kept in standby condition	13.39	1.83	5.48	0.0574
4115	Install controls to operate equipment only when loaded	7.73	0.59	5.26	0.0837
	sub-total	431.35			
<u>Insulation:</u>					
5511	Insulate tanks, vessels, lines, and process equipment	166.35	10.59	6.53	0.0498
5514	Cover and seal open tanks	7.84	1.99	7.36	0.0153
5331	Use optimum refrigerator thickness insulation for low temperatures	6.30	1.86	3.26	0.0248
5512	Increase or repair insulation thickness on process tanks, vessels, lines	2.56	1.39	8.68	0.0281
6255	Install or upgrade insulation on HVAC distribution systems (pipes, ducts, etc.)	0.08	1.24	0.62	0.3004
	sub-total	183.23			
<u>Ventilation Systems:</u>					
5521	Use minimum necessary ventilation for process purposes	121.28	2.48	10.17	0.0941
5123	Adjust or modify vents on process equipment to minimize energy usage	3.36	1.12	4.48	0.0716
	sub-total	124.64			
<u>Refrigeration Systems:</u>					
5336	Modify refrigeration system to enable compressor to operate at low pressure	65.69	3.24	9.33	0.0725
5335	Use highest acceptable temperature for process chilling or cold storage	6.15	1.08	6.81	0.0154
5333	Reduce infiltration to refrigerated areas/isolated hot process equipment	5.13	2.56	1.85	0.0682
5338	Eliminate or reduce frost formation on refrigerator evaporators	1.43	0.33	16.85	n/a
5339	Minimize the temperature of refrigeration condenser cooling water	0.07	0.88	1.80	0.0129
	sub-total	78.47			
<u>Other Miscellaneous Opportunities:</u>					
4121	Use most efficient equipment at its maximum capacity	58.84	2.22	10.77	0.0482
4122	Schedule to run equipment with full loads/use batch type drying ovens	36.79	1.56	12.64	0.1351
5214	Reduce flow rate of process fluids (e.g. drying air)	33.85	1.07	11.49	0.0434
5341	Reduce temperature of service or domestic hot water	26.63	5.18	2.02	0.0337
4141	Locate causes of demand charges and reschedule operations to avoid peak	19.21	9.00	1.13	0.0857
5121	Establish equipment maintenance schedule for or make necessary repairs	9.93	1.18	6.38	0.0838
4312	Evaluate energy use in packaging process/change to reduce energy-intensity	9.35	0.91	8.41	1.5121
5222	Use small number of high-output units vs. many small inefficient units	2.98	0.55	16.86	0.1175
6313	Use water coolers and vending machines efficiently	2.96	0.89	1.98	0.0979
5218	Use optimum temperature for hot processes - washing, drying, forming, etc.	2.96	1.19	4.91	0.0322
3351	Eliminate leaks in water lines, valves, storage tanks, and process equip.	1.54	0.69	2.89	0.0620
3311	Use minimum water for processes; cooling, washing, etc.	1.41	0.85	6.88	0.0849
3121	De-energize excess transformer capacity to avoid utility charges	1.34	1.20	4.61	0.0550
3141	Reduce load on electric conductors to reduce heat losses	0.99	0.78	8.99	0.1109
5311	Use minimum safe oven ventilation	0.82	1.19	7.88	0.0912
4125	Schedule baking times of small and large components to minimize energy use	0.89	0.58	7.38	0.1017
3312	Shut off cooling water when not required	0.69	0.65	8.27	0.4104
4142	Recharge batteries (fork trucks, etc.) during off-peak demand periods	0.13	1.57	0.34	0.0000
5221	Convert from batch to continuous operation	0.11	0.33	1.26	0.0788
5224	Reduce scrap production	0.06	0.71	1.23	0.0324
3352	Remove or close off unneeded water lines to avoid potential leaks/freezing	0.02	0.43	0.46	0.0531
5213	Avoid cooling process streams which subsequently must be heated, etc.	0.01	0.43	0.29	n/a
	sub-total	211.20			
	Total	4,803.42			

4.0 O&M Impact Analysis in the Pulp and Paper Industry

The analysis presented in Section 3.0 is based on resources that reviewed the electric energy consumption of all twenty of the industries comprising the manufacturing sector. In order to condense the large amount of energy consumption information associated with all 20 sectors into a presentable size, general categories describing components and processes common to many of the 20 industries were used as a means of presenting the information. While this is an efficient method of comparing component energy consumption between various industries, it does not provide a very accurate portrait of the processes consumption characteristics of a single industry. For the most part the electrical components utilized in the manufacturing industries are the same (motors, pumps, lighting, etc.), however, the environment in which they operate and the processes in which they are used can vary dramatically. Energy management attitudes and concerns also differ between industries. In order to determine whether differences such as these will have a significant affect on the results of the assessment of the resource potential that may be achieved through improvements to O&M practices, and to determine the accuracy of the previous results, a detailed examination of the energy consumption characteristics, O&M practices, and potential impacts of improvements to these practices in the pulp and paper industry was conducted. The pulp and paper industry was selected for this study because of its high electric energy consumption and because of the impact it has on the magnitude of the Pacific Northwest's electric energy consumption.

4.1 Energy Consumption Characteristics

Before the effect that improvements to O&M techniques may have on the pulp and paper industry can be assessed, a thorough understanding of where and how the electric energy is consumed is needed. The purpose of this section is to augment the previously presented data with information derived from resources which specifically addresses the pulp and paper industry.

Analysis of energy consumption at the component and process level is complex. No two plants, even if defined by the same four digit SIC, have identical process lines or equipment. Plants employ varying degrees of state-of-the-art technology, some of which can have a profound effect on the energy consumption rates within a plant. Energy use can also vary dramatically from plant to plant depending on the raw materials and processes used, the type and age of the equipment, the capacity utilization, and plant-specific operating practices. It is this diversity in manufacturing operations that makes energy analysis at the process level extremely difficult.

Because a single source which adequately examines process and equipment energy consumption could not be found, energy consumption characteristics of the pulp and paper processes were formed from a large number of references. Table 4.1 presents the process and equipment energy consumption information derived from available pulp and paper references. Anomalies in the information are attributed to the difficulty of gathering process energy consumption information. Process and component energy consumption figures are typically referred to in industry using specific energy consumption (or energy consumed per mass of product produced). In order to keep the form of the data consistent with previously collected information, specific energy consumption estimates were multiplied by annual estimates of the mass of material produced for the major processing steps.

As will be discussed in the following section, energy consumption at the component and processes level was found to be extremely inconsistent. Multiple consumptions estimates are given when contradictory information was found. Estimates for a single process sometimes varied by an order of magnitude. It is not known whether incongruities are due to errors in some information, due to differences in definitions of processes, or actual energy efficiency differences.

4.1.1 Component End Use

As illustrated in Table 2.5 the paper industry's electric loads are predominantly heavy motors used for pumps, mixing, and cutting. This fact is difficult to deduce from Table 4.1. Pulp and paper references provided little information on characteristics of electric consumption at the component level. The industry is primarily focused on optimizing processes as opposed to equipment. This is probably due to the fact that operating efficiencies of identical equipment used in different processes will be affected by the environment, loading conditions and other factors that change as a function of application.

4.1.2 Pulp and Paper Processes

The major paper production processes are pulping, bleaching, paper making, paper drying, and finishing. Of these pulping and the paper machine are the largest consumers of electric energy. The method of pulping plays an important role in characterizing the electric energy use of the pulping process.

Pulp is processed either chemically (Kraft or Sulfite process) or mechanically. While the general energy intensities of the three process are relatively close, the form of energy consumed differs dramatically. Kraft process plants use primarily thermal energy while mechanical pulp process are electric intensive, using as much as four times the electric energy per ton of processed product as the chemical processes. Column one in Table 4.1 shows the estimated specific energy consumption for various types of chemical and mechanical pulping processes. Currently 70% of pulp mills use a chemical process and 10% use a mechanical process (the remaining 20% is attributed to processing recycled paper products). This is reflected in Column 3 of Table 4.1 which shows chemical pulping having a higher annual electric energy consumption even though on a per mass product produced basis it is substantially less. In other words, even though chemical pulping consumes less energy per unit product than mechanical pulping, more paper is produced using chemical resulting in more electric energy being consumed by chemical pulping. However, due to its high yield, environmental benefits, lower capital, raw material, and operating costs of production, thermomechanical pulping is the fastest growing sector of the pulp and paper industry (Burwell 1986). Mechanical pulping electric energy consumption will correspondingly increase with increased use of mechanical pulping processes.

The electric consumption of the paper machine is due primarily to motors which are needed to operate the machine drives, pumps and other rotating devices required for operation. As shown in Table 4.1 the electricity consumption of the paper machine varies as a function of the type of paper product. The variation in energy consumption estimates is attributed to the inconsistent method of accounting for paper machine subprocesses. Not all references attributed the same subprocesses such as sheet formation, pressing, drying, coating, calendaring, and winding to the paper machine process resulting in substantially different energy estimates.

4.2 O&M Issues

Energy conservation measures typically considered by industry are equipment oriented. Some examples include retrofits, replacement with more efficient devices, fuel switching, and the addition of waste heat recovery devices. While these have certainly proven themselves as valuable methods of reducing energy consumption, another relatively untapped area from which large benefits can be reaped with minimal investment, is improvements to operation and maintenance procedures. Savings can result not only from the identification and correction of poor maintenance procedures but also from the implementation of advanced diagnostic and control technologies.

The amount of energy that can be saved by improving current O&M procedures is primarily a function of the maintenance techniques being practiced and the equipment and processes that are being maintained. In order to assess the energy-savings potential of improved O&M in the paper industry it was necessary to identify current industry O&M practices and the types of process and equipment affected by them.

4.2.1 General O&M Techniques

There are three basic O&M techniques used by the paper industry; corrective maintenance, preventive maintenance, and predictive maintenance. Corrective maintenance is the practice of waiting for a failure to occur before repairing or replacing a component. It is the oldest and the most commonly practiced method. Because of its "wait until failure occurs" approach, corrective O&M is the least efficient and most costly method. The high costs are a result of decreases in component lifetime due to continued improper operation, plant shutdowns required for repairs, and increased personnel required to perform the repairs.

A more effective and less costly approach is to search for symptoms indicative of a degradation in performance as opposed to a component failure. This preventative approach can, depending on the complexity of the operation and the amount of funding allocated to O&M, be worker or computer based. Preventive maintenance has been in use in the pulp and paper industry for over a decade and has proven to be cost effective. A preventive maintenance program initiated at Mid-Eastern Box Manufacturing Company resulted in an increase in production and a reduction in downtime of 10% (Reidel 1989). A survey of Swedish pulp and paper mills showed that a reduction in downtime of up to 50% could be attained after the introduction of a preventive maintenance program (Larson 1986). Depending on the situation at the start of a project, costs associated with computerizing maintenance varies from 0.5% to 4% of annual maintenance costs for the plant during the project time span.

The state-of-the-art O&M systems employ predictive maintenance practices. Predictive methods utilize advanced diagnostic and control techniques to anticipate degradation as opposed to evaluating degradation or identifying failure. These methods typically employ remote monitoring and computer diagnostic techniques. Such advanced sensing and control is currently being researched by the paper industry to monitor various paper making processes. The goal of the research is to optimize product yield and quality to process inputs, including energy. In general, these advanced developments are not driven by energy considerations, but energy efficiency usually improves as a by-product. Potential savings through process optimization and advanced control for the electric intensive paper machine has been estimated to be 10% to 20% (Mannisto 1986).

A survey of pulp and paper mills illustrates the diversity in the approach to O&M. On average, the percentage of personnel assigned to predictive and preventive maintenance falls between 8% and 20% of the maintenance work force (Yolton 1988). This indicates that the more effective predictive and preventive methods are not in widespread use but are becoming more accepted as their benefits are more fully understood. It has been estimated that when things are done to reduce maintenance costs, the savings potential is seldom less than a 1% to 2% increase in prime quality production output and a 20% reduction in maintenance costs (Idhammar 1988).

Regardless of which of the previously discussed maintenance approaches are used, the purpose of an O&M program in a pulp and paper plant remains the same: reduce emergency breakdowns, increase machine reliability and efficiency, and to reduce downtime and overtime with the overall goal of increasing production while decreasing operating costs. While the emphasis is more geared toward minimizing unscheduled outages, energy is wasted during these outages, and more energy is wasted when the plant is forced to operate above capacity to make up for the idle period. In addition, most of the procedures that make equipment and/or process more productive also result in a higher efficiency. In other words making operating and maintenance changes to reduce downtime and increase production will result in increased energy efficiency and thus decreased operating costs.

Prior to the energy crisis in the early seventies, maintenance was often looked upon by management as a necessary nuisance and maintenance expenses were at the bottom of budget priorities. As energy and operating costs have increased, the desire to reduce the number of unscheduled shutdowns and to increase the time between planned shutdowns has elevated the awareness of the importance of maintenance in the daily operation of paper plants. This trend has been compounded by increased environmental restrictions on the industry. The required energy to control environmental effects associated with production techniques may be significant. As a result, existing and proposed environmental standards are playing a significant role in the design of pulp and paper energy programs.

4.2.2 O&M Practices in the Pulp and Paper Industry

A listing of potential electric energy reduction items identified for the pulp and paper industry by Ford, Bacon and Davis is listed in Table 4.2 (Sittig 1977). Of one hundred and thirteen energy conservation opportunities only thirty four are electric in nature. Electric energy represents less than 16% of the total energy consumed by the paper industry, correspondingly most conservation measures are aimed at decreasing the use of thermal energy (Burwell 1986). Net mill energy savings is the important standard; if savings in one application will be offset by increased energy requirements elsewhere then the application may not be cost effect. It is important to realize that even though this document addresses only electric energy use, the total energy cycle, electrical and thermal, must be considered before pursuing any energy conservation opportunity.

4.3 O&M Impacts

A review of pulp and paper trade papers was conducted to gain insight into the savings potential of operation and maintenance related electric energy conservation opportunities in the paper industry. Most of the literature presented results of specific conservation actions taken at particular plants. It appears that, with the exception of the EADC work, little effort has been made to consolidate

potential energy savings information. This section will present the information gathered in the literature search and compare it with the EADC pulp and paper information.

Over 100 issues of the paper trade journals, *Pulp & Paper* and the *Tappi Journal*, were examined for articles pertaining to electric savings achievable through O&M improvements. Very little quantifiable information was found. The majority of the articles pertaining to O&M issues either discussed the benefits in a very general manner or discussed maintenance impacts for specific equipment. Most of the equipment specific articles were concerned with the maintenance of the paper machine and associated motor drives. This is consistent with the TAG electricity consumption characteristics of the paper industry and with the results of the analysis of the EADC data. Figure 4.1 summarizes the national O&M conservation potential for the pulp and paper industry previously presented in Figure 3.12. The end-use categories of the DIECO recommendations, which identify over 500 million kWh/yr savings, have also been included on the chart.

4.3.1 The Paper Machine

The paper machine is one of the most critical elements of the paper manufacturing cycle. The machine operates in a dynamic, constantly changing chemical environment that is prone to mechanical failure. It has been estimated that one minute of downtime for a paper machine causes a marginal loss of \$200. In a single year the loss is typically around \$3 to \$4 million for each paper machine with the maintenance and repair costs of this complex device being as high as 3% to 6% of the total revenues of a mill (Mattson and Virtanen 1989). In addition to fewer unscheduled downtimes, more time between scheduled downtimes, and less overall downtime, benefits of improved maintenance programs have also included higher quality paper and increased production through faster machine speeds. As a result, insuring proper operation of the paper machine through rigorous and often times advanced maintenance techniques is an industry priority. The payoffs of implementation of such advanced maintenance programs have been documented. For example, in a Norwegian paper mill, after adopting a stringent maintenance program, downtime of paper machines due to technical failures decreased by an average of 3.5% resulting in a production rise worth nearly \$1.5 million (Larson 1986).

Several predictive maintenance systems have been developed and implemented in the paper industry to continuously monitor key parameters of the paper machine and provide valuable information used to avoid unexpected shutdowns by assessing actual equipment condition and their probable failure repair date. The following electronic measurements can be made and analyzed in real time: oil flow to the bearings, oil and bearing temperatures, vibration, moisture content of the oil, pressures in oil system, pressure differential across filters, and quantities of seal water in the stuffing boxes of pumps and vacuum pumps (Venalainen 1989).

4.3.2 Rotating Equipment

Many of the measurement points mentioned above are directly concerned with or relate to motor operation. In general, the paper industry heavily depends on rotating equipment such as pumps, compressors, drives, crushers, cutters, fans and turbine gears. It employs more rotating equipment per unit of production than any other manufacturing industry (Orlowski 1986). Even though rotating equipment can make up between 30% to 40% of the total maintenance budget of a paper plant, less than 10% of NEMA frame motors in the pulp and paper industry serve 100,000 hours before their

first failure. In fact, many motors fail in less than 25,000 hours (approximately three years) (Orlowski 1986). With motor failure being the leading cause of lost time for the paper machine, proper maintenance of motors has become a priority of the paper industry, not only to decrease downtime due to failure but also to decrease operating costs. A 50% cut in the maintenance budget will enhance a typical paper company's bottom line by \$20 to \$30 million and improve earnings by 10% to 13% (Orlowski 1986). These estimates do not include downtime, production loss or disruptions. The implementation of even a simple computer part and maintenance tracking system can result in substantial savings. Such a preventive maintenance system employed at a Union Camp paper mill reduced motor repair costs by 30% and downtime between 50% and 60% (Cortes 1988).

Many of the advanced motor maintenance systems used in paper mills monitor the wear of bearings. Bearings are often times the limiting factor determining the reliability and lifetime of rotating equipment. Less than 10% of all bearings reach or exceed their minimum life expectancy and 30% to 40% of all motor failures in the paper industry are due to bearings (Orlowski 1986). A common method of monitoring bearing wear is through the use of vibrational analysis. Using bearing failure signatures which indicate the current condition of the bearings, a paper machine was repaired before failure resulting in a savings of \$72,016 from the previous failure repair cost of \$118,110. This preventive repair approach resulted in a savings of 61% (Orlowski 1986). Another method of improving bearing operation is to isolate them from the harsh paper mill environment and use high-performance synthetic lubricants. Broad-scale testing of this approach indicates a 60% to 70% reduction in catastrophic failures. These results indicate a possible 50% reduction in rotating equipment maintenance and a 230% return on investment for conversion to better bearing maintenance methods (Orlowski 1986).

Maintaining proper seals is also an important issue in insuring the optimal operation of rotating equipment. Most of the rotating machinery require sealing to prevent loss of product or excessive dilution by leaking seals. Only 5% of all mechanical seals in a typical pulp and paper mill achieve normal life. Of the 95% that fail prematurely, 15% fail due to application error, 20% to installation error and 60% to operation error (Bosar and Krogel 1988). Because sealing failures do not have the same dramatic effect on operations as bearing failures (i.e., do not typically result in a forced shutdown), their maintenance has been to some extent neglected. This is indicative of an industry which is often more focused on reducing downtime than on improving operating efficiency.

From the literature reviewed, it appears that most of the emphasis in the pulp and paper industry is on reducing downtime; however, some cooperative efforts have been made between the industry and utilities to examine the potential of increasing the electrical efficiency of equipment. For example, Boise Cascade and Pacific Power and Light Co. examined the potential efficiency improvements in pumping systems. The results of the study indicated that energy savings were available even in recently designed and installed pumping systems. Trimming the size of the impellers was found to be the most expedient method of improving the electrical efficiency of the pumping systems. This procedure led to a reduction in annual cost of electricity of 2.5% to 8.2% with a simple payback period of 5.2 to 15.7 months (assuming a \$2,500 cost to trim each impeller) (Gault and Rucker 1986). In a similar study, trimming the impeller of oversized induced-draft fans required in a pulp mill's lime kiln, resulted in an annual energy savings of \$110,000 (370-hp savings) for a cost of \$35,000 (Perry 1989).

4.4 Conclusions

Generalized process information, such as that found in the IMIS database, does a poor job of characterizing process energy consumption in the pulp and paper industry. Energy consumption estimates made within the industry give a better feel for how electric energy is consumed as a function of process. However, process consumption estimates can vary dramatically because of the variety of types of paper plants, process utilized, size, and operating methods. Because the paper industry tends to categorize its equipment as a function of the process, overall component electricity consumption data is better characterized in the generalized references discussed in Section 3.0.

Energy conservation opportunities developed specifically for the pulp and paper industry are almost identical to the generic DIECO recommendations. This was to be expected since O&M procedures are component driven. While processes differ drastically in the various manufacturing industries, the equipment used in the processes are basically the same. In other words, the approach to O&M is universal across the manufacturing sector. It can be concluded that the analysis using the EADC and DIECO information to determine the potential electricity savings addresses most of the conservation opportunities available to the respective industries.

The pulp and paper industry is aware of the importance of operation and maintenance and has already adopted some of the most advanced housekeeping methods, however, there still remains substantial opportunity for increasing the electrical efficiency of the industry. The industry has the third largest potential for electric energy savings through improvements in O&M procedures at approximately 15,000 million kWh annually (refer to Figure 3.14). This study has shown that the primary savings will be achieved through improved maintenance of motor drives.

Even though the driving factor in the industry appears to be reducing downtime, this study shows that the awareness of the potential for reducing operating costs through reduced electric consumption within the paper industry appears to be growing. Only with this realization can the potential electric energy savings in the industry be achieved.

Figure 4.1. Pulp and Paper O&M Energy Conservation Potential

Table 4.1. Process and Component Energy Consumption

Process	Equipment	Electric Energy (kWh/ton)	Production (million tons)	Electricity Consumption (million kWh)	Energy Reference	Production Reference
Wood Preparation		108.0	76.34	7,911.12	A.D. Little Inc. 1976	BNL 1984
Debarking		24.0	76.34	1,808.28	Gleese 1988	BNL 1984
1. mechanical		23.0	76.34	1,732.81	Brown et al. 1985	BNL 1984
	ring barter					
	drum barter					
	tumble drum					
	parallel drum					
2. hydraulic jet						
Chipping	high pressure	34.0	34.04	1,157.43	Gleese 1988	Elaahi and Lowitt 1988
		43.0	34.04	1,463.81	Brown et al. 1985	Elaahi and Lowitt 1988
	chipper					
	vibrating screens					
	rechipper					
	bark boiler					
Pulping		234.3	56.80	13,331.87	Gleese 1988	Elaahi and Lowitt 1988
1. chemical						
a. kraft		100.0	42.36	4,236.00	Gleese 1988	Kahane 1986
		380.0	42.50	16,150.00	Kahane 1986	Elaahi and Lowitt 1988
		500.0	42.50	21,250.00	Temanex Consulting Inc. 1987	Elaahi and Lowitt 1988
		115.0	42.50	4,887.50	A.D. Little Inc. 1976	Elaahi and Lowitt 1988
		278.0	42.50	11,815.00	BNL 1984	Elaahi and Lowitt 1988
		400.0	42.50	17,000.00	Pierce and Blazer 1982	Elaahi and Lowitt 1988
i. batch digestion						
	digester-heated vessel					
	blow tank					
	heat exchanger					
	strainers					
	pumps					
ii. continuous digestion						
	presteaming vessel					
	flash tank					
	heat exchanger					
	screens					
	pumps					
b. sulfite	batch digester	360.0	1.82	631.80	Kahane 1986	Elaahi and Lowitt 1988
		278.0	1.82	485.36	BNL 1984	Elaahi and Lowitt 1988
		400.0	1.82	648.00	Pierce and Blazer 1982	Elaahi and Lowitt 1988
2. mechanical		1,460.0	11.80	16,820.00	Gleese 1988	Elaahi and Lowitt 1988
a. stone groundwood		1,450.0	4.81	6,978.85	Gleese 1988	A.D. Little Inc. 1976
		1,730.0	4.81	8,328.49	Kahane 1986	A.D. Little Inc. 1976
		1,400.0	4.81	6,736.20	Temanex Consulting Inc. 1987	A.D. Little Inc. 1976
		1,574.0	4.81	7,575.88	BNL 1984	A.D. Little Inc. 1976
		2,000.0	4.81	9,628.00	Pierce and Blazer 1982	A.D. Little Inc. 1976
		568.0	4.81	2,676.03	Brown et al. 1985	A.D. Little Inc. 1976
b. thermomechanical	grinder	3,800.0	2.20	7,820.00	Gleese 1988	Kahane 1986
		2,000.0	2.20	4,400.00	Temanex Consulting Inc. 1987	Kahane 1986
		1,820.0	2.20	4,004.00	BNL 1984	Kahane 1986
		2,200.0	2.20	4,840.00	Pierce and Blazer 1982	Kahane 1986
	preheater-steam refiner	884.0	2.20	1,844.80	Brown et al. 1985	Kahane 1986
c. refiner mechanical pulp		1,800.0			Gleese 1988	
d. chem. thermomech.	double-disc mills	884.0			Brown et al. 1985	
		2,200.0			Gleese 1988	
e. pressure groundwood		1,500.0	1.87	2,508.00	Temanex Consulting Inc. 1987	A.D. Little Inc. 1976
	grinders	558.0	1.87	829.63	Brown et al. 1985	A.D. Little Inc. 1976
3. semi/chemimechanical	compressors	680.0	4.40	2,982.00	Kahane 1986	Kahane 1986
		816.0	4.40	2,710.40	A.D. Little Inc. 1976	Kahane 1986
		200.0	4.40	880.00	Pierce and Blazer 1982	Kahane 1986
neutral sulfite semichem.		555.0	3.87	2,148.74	Gleese 1988	A.D. Little Inc. 1976
	oven					
	disc refiners					
	blow tank					
	mechanical repulper					
Pulp drying		200.0	56.80	11,360.00	Gleese 1988	Elaahi and Lowitt 1988
	air float dryer					
	cylinder					
	flash drying	70.0			Gleese 1988	

Table 4.1. (contd)

Process	Equipment	Electric Energy (kWh/ton)	Production (million tons)	Electricity Consumption (million kWh)	Energy Reference	Production Reference
Causticizing Washing		80.0	42.35	2,541.00	Gleeson 1988	Kahane 1988
		11.7	58.90	683.73	Gleeson 1988	Elashli and Lowitt 1988
		80.0	58.90	2,848.00	Gleeson 1988	Elashli and Lowitt 1988
		73.0	58.90	4,183.70	Brown et al. 1985	Elashli and Lowitt 1988
Bleaching		32.2	58.90	1,832.18	Gleeson 1988	Elashli and Lowitt 1988
		800.0	58.90	28,480.00	Gleeson 1988	Elashli and Lowitt 1988
		117.0	58.90	6,857.30	BNL 1984	Elashli and Lowitt 1988
	for mechanical pulping	80.0	4.81	388.04	Gleeson 1988	A.D. Little Inc. 1978
		43.0	4.81	208.88	Brown et al. 1985	A.D. Little Inc. 1978
	for Kraft pulping	800.0	42.50	21,250.00	Gleeson 1988	Elashli and Lowitt 1988
		85.0	42.50	4,037.50	A.D. Little Inc. 1978	Elashli and Lowitt 1988
		125.0	42.50	5,312.50	Pierce and Blazer 1982	Elashli and Lowitt 1988
		117.0	42.50	4,872.50	Brown et al. 1985	Elashli and Lowitt 1988
	for sulfite pulping	100.0	1.82	182.00	Pierce and Blazer 1982	Elashli and Lowitt 1988
		117.0	1.82	189.54	Brown et al. 1985	Elashli and Lowitt 1988
	steam heated towers washers & showers vacuum pumps					
Stock Prep./Refining		80.8			Gleeson 1988	
		420.0			Gleeson 1988	
	repulper (mech.)	348.0			A.D. Little Inc. 1978	
		240.0			Pierce and Blazer 1982	
	1. refiner-steam heated	28.0			Brown et al. 1985	
	conical single-disc double-disc pumps					
2. chemical addition blending						
Paper Machines		108.4	75.34	8,187.28	Gleeson 1988	BNL 1984
		500.0	75.34	37,672.00	Temanex Consulting Inc. 1987	BNL 1984
Product		400.0	75.34	30,137.80	Gleeson 1988	BNL 1984
newsprint		300.0	0.01	1.89	BNL 1984	BNL 1984
		500.0	0.01	3.15	Pierce and Blazer 1982	BNL 1984
fine writing paper		350.0	0.01	5.17	BNL 1984	BNL 1984
		700.0	0.01	10.35	Pierce and Blazer 1982	BNL 1984
liner board		325.0	0.02	6.82	BNL 1984	BNL 1984
corrugated medium		325.0	0.02	6.82	BNL 1984	BNL 1984
boxboard		375.0	0.01	8.00	BNL 1984	BNL 1984
		500.0	0.01	8.00	Pierce and Blazer 1982	BNL 1984
sanitary paper/tissue		375.0	0.01	1.81	BNL 1984	BNL 1984
		750.0	0.01	3.62	Pierce and Blazer 1982	BNL 1984
construction paper		400.0	0.01	2.80	BNL 1984	BNL 1984
		200.0	0.01	1.40	Pierce and Blazer 1982	BNL 1984
market pulp		100.0	0.00	0.16	BNL 1984	BNL 1984
		200.0	0.00	0.32	Pierce and Blazer 1982	BNL 1984
Processes						
1. Paper machine						
a. sheet formation						
	Fourdrinier	175.0	75.34	13,185.20	Gleeson 1988	BNL 1984
		148.0	75.34	11,000.22	Brown et al. 1985	BNL 1984
	vacuum	75.0	75.34	5,650.80	Temanex Consulting Inc. 1987	BNL 1984
	machine drive	125.0	75.34	9,418.00	Temanex Consulting Inc. 1987	BNL 1984
b. pressing						
	vacuum	150.0	75.34	11,301.60	Temanex Consulting Inc. 1987	BNL 1984
	machine drive	100.0	75.34	7,534.40	Temanex Consulting Inc. 1987	BNL 1984
		175.0	75.34	13,185.20	Brown et al. 1985	BNL 1984
c. drying						
		50.0	75.34	3,767.20	Temanex Consulting Inc. 1987	BNL 1984
		55.0	75.34	4,388.55	Brown et al. 1985	BNL 1984
	contact dryer convaction dryer radiation dryer microwave infrared					
	impulse				Gleeson 1988	
d. coating				885.19	BNL 1985b	
	air knife coater blade coater					
e. calendering						
	rollers					
f. winder						

Table 4.1. (contd)

Process	Equipment	Electric Energy (kWh/ton)	Production (million tons)	Electricity Consumption (million kWh)	Energy Reference	Production Reference
2. Cylinder		80.0	75.34	4,820.84	Gleeson 1965	BNL 1984
a. sheet formation						
b. pressing						
c. drying						
d. calenders						
e. coater						
f. winder						
Supersalendering						
Auxiliary						
1. steam & power gen.	turbine generators boilers stoker pulverized-coal					
a. direct heating						
b. indirect heating	tube banks cylinders jackets heat exchangers pumps condensate return					
2. process control	digestor kilo paper machine recovery boilers dryer					
3. pollution control				447.80	BMI 1985b	
4. lighting				1,780.36	BMI 1985b	
5. space conditioning						
Chemical Recovery		170.0	42.35	7,189.50	A.D. Little Inc. 1978	Kahane 1986
kraft process	evaporators direct contact long-tube vertical indirect-contact recovery boiler pumps rotary kiln rotary coolers					

Table 4.2. Pulp and Paper Energy Conservation Opportunities

<u>Classification</u>	<u>Energy Conservation Opportunity</u>
General Mill - Compressed Air Systems	<ul style="list-style-type: none"> • Reduce wasteful use of compressed air by O&M personnel
General Mill - Insulation	<ul style="list-style-type: none"> • Reevaluate insulation installed using past low-energy cost criteria, and install additional insulation where justified on a cost versus energy-saving basis • Reevaluate piping, equipment and vessels that are not presently insulated, and install additional insulation where justified on a cost versus savings basis
General Mill - Maintenance	<ul style="list-style-type: none"> • Repair compressed air leaks • Repair water and process leaks • Maintain pump and agitator seals in good condition to reduce wastage • Repair or replace damaged insulation • Increase maintenance planning and preventive maintenance
General Mill - Electrical	<ul style="list-style-type: none"> • Match induction motor horsepower as closely as possible to load. Induction motors operate at maximum efficiency and power factor at full load • Install photocell or time switch on outdoor lights • Use high pressure sodium lights in place of incandescent or mercury vapor, except in office areas, low ceiling areas, and emergency lighting • Use "spot" lighting and avoid high general area lighting as much as possible
Pulp Mill - Wood Receiving and Handling	<ul style="list-style-type: none"> • Transfer chips and bark by belt rather than pneumatic conveyor
Pulp Mill - Bleaching	<ul style="list-style-type: none"> • Operate bleach plant with pulp at maximum feasible consistency to reduce pumping horsepower and heating system consumption • Utilize computer control to optimize the operation for maximum energy and chemical consumption

Table 4.2. (contd)

<u>Classification</u>	<u>Energy Conservation Opportunity</u>
Power Plant - Electrical Generation & Distribution	<ul style="list-style-type: none"> • Minimize purchased electrical power by use of automatic purchased power/back-pressure power/selective load shedding control • Maximize condenser efficiency by maintaining cleanliness of tubes • Maximize condenser efficiency by maintaining steam jet ejectors of vacuum pumps in efficient manner • Maximize condenser efficiency by minimizing air leakage into vacuum system • Maximize station efficiency by computer control of multiple generating units for most favorable distribution of load
Power Plant - Black Liquor Evaporators	<ul style="list-style-type: none"> • Maintain cleanliness of condenser tubes to obtain highest vacuum • Maintain condenser air-ejector equipment to obtain highest vacuum • Minimize air leakage into vacuum system • Maintain condenser steam jet ejectors in efficient condition by testing, by inspection during shutdowns, and replacement of worn jets when indicated • Operate condenser steam jet ejectors at proper pressure for maximum efficiency
Paper Mill - Stock Preparation	<ul style="list-style-type: none"> • Design/operate saveall systems to produce wash water of sufficient cleanliness and reliability for general reuse in stock preparation and paper mill (e.g., fourdrineir showers, saveall showers, headbox showers, dilution mechanical pulping operations, etc.)
Paper Mill - Paper Machine	<ul style="list-style-type: none"> • Use variable speed from fan pump drive on multigrade machine • Evaluate and optimize pressure drop across stock cleaners and screens • Optimize press efficiency • Optimize paper machine hood system • Use computer to control
Paper Machine - Building Air System	<ul style="list-style-type: none"> • Operate air makeup and exhaust units only when necessary • Provide building insulation to reduce heating and ventilation requirements

5.0 Conclusions and Recommendations

The results of this analysis identify a significant electric resource potential available through O&M activities both nationally and for the Pacific Northwest. This section will focus on the results for the Pacific Northwest. The overall potential in the Pacific Northwest identified in this study range from a low of 4,903 million kWh/yr (559.7 aMW), from the EADC database analysis, to as much as 7,414 million kWh/yr (846.7 aMW), from the general literature review (Table 3.1, Smith 1978).

The equipment category with the largest energy-savings potential identified in this study is Air Compressors and Compressed Air Systems, followed closely by Motors and Motor Drive Systems. Table 5.1 identifies the Pacific Northwest energy-savings potential by major DIECO end-use category from the EADC database. The specific O&M measure with the largest potential is repairing leaks in compressed air lines (DIECO 3231). The ten industrial O&M measures with the largest potential from the EADC database are listed in Table 5.2.

Overall, the results from the EADC database analysis are not fairly consistent with the results of the general literature review. In a case-by-case comparison, the estimated potential energy savings resulting from compressed air systems is 1,482 million kWh/yr (169.2 aMW) from the EADC analysis and 416 million kWh/yr (47.5 aMW) from the general literature review (Table 3.1, Singh et al. 1990). In the specific measure, repairing compressed air leaks, the potential energy savings is 1,040 million kWh/yr (118.7 aMW) from the EADC analysis compared to between 165 and 908 million kWh/yr (18.8 and 103.7 aMW) from the general literature review (Table 3.1, Singh et al. 1990 and Patel 1991). Table 5.3 compares the findings of the general literature review to the EADC analysis for those measures which can be easily related.

The industry with the largest energy-savings potential in the Pacific Northwest through O&M activities is Paper and Allied Products (SIC 26). This can be readily seen in Figure 3.18. The primary aluminum industry (SIC 3334), the largest energy consumer in the Pacific Northwest, was excluded from the Pacific Northwest application of the EADC analysis and therefore could not be included in the study. The O&M resource potential within the primary aluminum industry is an unknown and merits further analysis.

The recommendation based on the results of this study is to proceed with the additional tasks to this project to verify the O&M electric energy resource potential of air compressors and compressed air systems. A second alternative is motors and motor drive systems. Both of these categories offer significant energy-savings potential that could be readily achieved and maintained.

Table 5.1. Summary of Pacific Northwest Industrial O&M Energy-Savings Potential, 1990

<u>Major DIECO End-Use Category</u>	<u>PNW Potential (million kWh/yr)</u>	<u>PNW Potential (aMW)^(a)</u>
Air compressors and compressed-air systems	1,482.37	169.2
Motors and motor drive systems	1,129.63	129.0
Lighting	813.09	92.8
HVAC systems	449.44	51.3
Equipment scheduling and control systems	431.35	49.2
Insulation	183.23	20.9
Ventilation systems	124.64	14.2
Refrigeration systems	78.47	9.0
Other miscellaneous opportunities	<u>211.20</u>	<u>24.1</u>
Total	4,903.42	559.8

(a) 1 aMW = 8.76 million kWh/yr

Table 5.2. Top Ten Industrial O&M Energy-Saving Measures in the Pacific Northwest, 1990

<u>DIECO</u>	<u>DIECO Description</u>	<u>End-Use Equipment</u>	<u>PNW Potential (million kWh/yr)</u>	<u>PNW Potential (aMW)</u>
3231	Eliminate leaks in lines and valves carrying compressed-air or other gases	Air Compressors	1,040.46	118.8
5122	Improve lubrication practices for motor-driven equipment	Motors	613.34	70.0
5355	Use energy-efficient belts and other improved mechanisms	Motors	491.69	56.1
4112	Reduce operating time of equipment to the minimum required/install timers	Controls	278.81	31.8
6121	Install timers or motion sensors on little used lights or initiate schedule	Lighting	253.62	29.0
6111	Disconnect lighting fixtures, delamp, or use lower output lamps for min. light needed	Lighting	248.16	28.3
3221	Install compressor air intake in coolest location	Air Compressors	190.97	21.8
3211	Reduce the pressure of compressed air system to the minimum required	Air Compressors	175.13	20.0
5511	Insulate tanks, vessels, lines, and process equipment	Insulation	166.35	19.0
6244	Install or use timers or thermostats for space conditioning	HVAC	146.79	16.8

Table 5.3. Comparison of O&M Findings for the Pacific Northwest

O&M Measure	EADC Potential (million kWh/yr)	Other Sources Potential (million kWh/yr)
General Air Compressors and Compressed Air Systems	1,482	416
Eliminate Leaks in Compressed Air Systems	1,040	165 to 908
Relocate Compressed Air Intake to Cool Location	191	116
General HVAC Systems	449	522
Improve Lubrication Practices	613	238 to 4,339
Use Energy-Efficient Belts	492	346 to 487

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