POWERCOMP ASSOCIATES LTD.
~~BOX 318, RPO UNIVERSITY~~
SASKATOON, SASKATCHEWAN
CANADA ~~S7N 4J8~~ S7J 2R6

R. BILLINTON, PRESIDENT
R. J. FLEMING
M. S. SACHDEV

3 MACLEAN CRES.
(306) 373-1836
(306) 966-5280

October 31st, 2001.

Mr. Bruce Hinton, P.Eng.,
Resource Planning & Market Analysis Dept.,
Power Planning and Operating Division,
Manitoba Hydro,
820 Taylor Avenue,
P.O. Box 815,
Winnipeg, Manitoba,
R3C 2P4.

Dear Bruce:

Please find enclosed my draft report entitled Manitoba Customer Interruption Cost Evaluation . It would be appreciated if you would give me a call after you have had a chance to look at it.

Best Wishes.

Yours truly,

RB/jb
Encl.

R. Billinton, P.Eng.,
President.

MANITOBA CUSTOMER INTERRUPTION COST EVALUATION

1. Introduction

There is a wide variety of customer impacts resulting from electric service interruptions. These impacts can be classified in the following ways. Direct economic aspects are those impacts which result directly from cessation of supply and include lost production, idle but paid for resources, process restart costs, spoilage of raw materials or food etc.. Direct social aspects include customer inconveniences, loss of leisure time, uncomfortable building temperatures and personal injury or fear etc. There is also a range of indirect impacts which arise and are difficult to categorize as being either economic or social. These include the costs related to civil disobedience and looting during an extended blackout etc. The above impacts are all short term in that they manifest themselves at the time of the interruption. A further set are more long term and can be identified as being adaptive responses or mitigation taken to reduce or avoid further outage costs. These include customer installation of interruptible power supplies, involvement in co-generation or standby power supplies or relocation to an area of perceived higher reliability.

The cost of an interruption in electricity supply to a particular customer is related to the degree to which the activities interrupted are dependent on electricity. This dependence is a function of both customer and interruption characteristics. Important factors such as the type of customer, and the nature of the activity, size of the operation and type, and the energy dependence as a function of the time of day etc. have considerable influence on the resulting costs. The costs associated with power supply unreliability are influenced by the duration and frequency of outage events, the time of interruption occurrence, the availability of advance warning information and the extent of the outage. The impact of an outage is also dependent on the attitude and preparedness of customers, which relates to existing reliability levels and customer previous experiences with losses in electricity supply.

Customer interruption costs are also influenced by the type of the interruption event in regard to how widespread is the interruption, its cause and its predictability. Localized outages affect a relatively small number of customers in which case, the social effects are likely to be small or non-existent. A widespread outage affecting a region could have significant associated social costs. The causes of an outage can be very important if it gives rise to multiple lengthy outages or creates additional societal effects. This was the case with Ice Storm 98 which affected eastern Ontario and the Montreal area of Quebec. The interruptions that have the highest impact on customers are those that occur randomly. In these cases, the times of occurrence and the interruption durations are uncertain and unpredictable. Advance warning information can significantly reduce customer irritation and outage costs. There is a degree of predictability associated with interruptions or events which result in a shortage of generation. In these cases, it may be possible to shed a portion of the system load. In these cases, both the degree of warning and the duration of the interruption seen by individual customers are somewhat predictable and under the control of utility. This type of situation is illustrated by the Auckland power failure in 1998. After the initial unpredictable event, the local utility was able, after a couple of days, to provide predictions of the likelihood of outages and the restoration of supply.

A variety of methods have been utilized to evaluate customer impacts due to interruptions. They can be generally grouped into the three broad categories of indirect analytical evaluation, case studies of blackouts and customer surveys. Indirect analytical techniques are reasonably straightforward to apply but are severely limiting and often involve unrealistic assumptions. Information on actual case studies is extremely limited and is very location specific. Analysis of the 1977 New York blackout considered both direct and indirect short-term costs. The results clearly indicated that the indirect costs greatly exceeded the direct costs. Considerable information is available on direct short-term customer interruption costs obtained by customer surveys. The strength of the approach is that the customer is probably in the best position to assess the economic costs associated with power failures. The survey method is considered to be the favored approach by utilities requiring interruption cost data for planning purposes. The data used in subsequent sections of this report were obtained from detailed customer surveys

conducted in Canada by the Power System Research Group at the University of Saskatchewan.

The development of an appropriate cost model involves the transformation of the original raw data from customer surveys into a suitable form for application in predictive assessment. The most common form of cost normalization is to represent the costs in forms of $/interruption, $/kW of peak load or maximum demand, $/kWh of annual energy consumed or $/kWh of unserved energy. The raw data obtained for each customer can be processed to produce cost functions for each customer group. This can be done at the sub-sector level using the Standard Industrial Classification (SIC) protocol utilized by Statistics Canada. The SIC customer data can be aggregated to produce customer cost functions at the sector level, i.e. residential, commercial, industrial and agricultural sectors. The cost functions at this level are known as Sector Customer Damage Functions (SCDF). The most common form of SCDF is to portray the interruption cost in $/kW of peak load as a function of the outage duration. This form of SCDF can be further transformed into one utilizing $/kWh of unserved energy.

The customer classifications utilized in this study were provided by Manitoba Hydro. The list of customer classes together with their monthly and annual energy consumption is shown in Table A-1 in the Appendix. Figures A.1 to A.20 in the Appendix show the CDF in $/kW interrupted for these customer classes. These data were taken from [1,2]. The relevant cost data from these reports [1,2] were escalated to bring them to 2001 values using Consumer Price Index data provided by Manitoba Hydro.

Figure A.1 shows the residential SCDF used in this study. Figures A.2 to A.12 show the commercial SIC customer cost functions. Figures A.13 to A.20 show the industrial SIC cost functions. The numerical values are given in Tables 1.1 to 1.3. The individual SIC cost functions are designated as ICDF in this report.

Table 1.1 Residential SCDF.

Duration	hours	SCDF [$/kW]
2 sec.	0.000555556	2.2E-05
1 min.	0.016666667	0.00522
20 min.	0.333333333	0.03362
1 hr.	1	0.19665
2 hr.	2	0.65656
4 hr.	4	2.19212
8 hr.	8	4.83825
24 hr.	24	22.0701

Table 1.2. Commercial ICDF.

Hours	Offices	Restaurant	Grocery Stores	Retail Outlets	Warehouse	Schools	College	Health Facilities	Hotels & Motels
0.00056	1.8369	0.0002	0	0.4056	0.2923	0.2032	0.2032	0.0914	0.0561
0.01667	2.6334	20.05	8.5269	0.4457	1.6749	0.3129	0.3129	1.1426	0.0561
0.33333	3.6165	26.339	17.711	12.674	2.0603	0.4575	0.4575	10.573	0.5465
1	8.0068	43.335	28.293	38.022	15.151	1.7095	1.7095	22.952	1.5134
2	13.764	63.58	52.189	130.92	22.391	3.3278	3.3278	44.467	2.074
4	23.662	95.371	305.32	197.97	44.422	6.4778	6.4778	86.148	3.9589
8	40.676	131.96	389.57	403.36	83.909	12.61	12.61	166.9	12.227
24	95.998	197.63	430.66	515.23	165.83	36.241	36.241	476.08	21.441

Table 1.2. (cont.)

Hours	Bulk Apartments	GS Housing & Services	MISC Commercial	Commercial Non-Building	Border Sales
0.000556	2E-05	0	0.2923	0.2923	0.2923
0.016667	0.0052	0.2853	1.6749	1.6749	1.6749
0.333333	0.0336	5.7065	2.0603	2.0603	2.0603
1	0.1966	16.454	15.151	15.151	15.151
2	0.6566	32.907	22.391	22.391	22.391
4	2.1921	67.485	44.422	44.422	44.422
8	4.8382	136.64	83.909	83.909	83.909
24	22.07	170.05	165.83	165.83	165.83

Table 1.3. Industrial ICDF.

Hours	Agriculture	Mining	Food & Beverage	Pulp & Paper	Chemicals & Treatment	Petroleum & Oil	Primary Metals	MISC Industrial	Industrial Non-Building
0.000556	0.0006	2.002	0.9509	0.014	0.768	4.0375	1.56	16.96	16.96
0.016667	0.0042	2.013	1.3983	12.44	0.768	4.8139	1.68	16.96	16.96
0.333333	0.874	1.787	5.8456	13.96	2.276	109.02	2.08	17.90	17.90
1	1.620	2.81	18.65	28.74	4.371	259.46	3.32	19.88	19.88
2	2.138	4.00	34.401	35.59	9.410	261.94	4.13	45.79	45.79
4	2.822	6.232	62.688	70.21	23.99	275.48	7.04	51.81	51.81
8	4.744	16.86	126.9	92.88	58.22	292.3	22.67	90.85	90.85
24	10.80	38.89	308.96	94.28	90.09	367.93	37.05	97.97	97.97

The cost functions displayed in Tables 1.1 to 1.3 and Figures A.1 to A.20 clearly show that the cost associated with a power failure will vary considerable depending on the kind of customer interrupted and the duration of the outage. The ICDF can be aggregated based on their relative energy or power consumption to produce sector values designated as SCDF. The aggregation is normally done using relative power consumptions for short durations and relative energy consumptions for durations longer than one hour. The energy consumption values shown in Table A.1 were used in this study. The SCDF therefore provide average cost functions for all customers in each sector. A single cost function was used for all the residential customers in that sector.

The SCDF can be further aggregated to provide a composite customer damage function (CCDF) to represent the outage cost characteristics of all the customers in the system. Its use in a cost assessment analysis therefore assumes that the effect of an outage is assigned to all the customers in the system on a relative energy consumption basis. This aspect is discussed in more detail later in this report.

The following section presents the SCDF and CCDF using the aggregate annual energy data for the assigned customer classes.

2. Annual Analysis

The relative annual energy consumption for the assigned customer classes are shown in Table B.1 in the Appendix. These data were used in conjunction with the ICDF for the commercial and industrial sectors to produce the SCDF shown in Figure 2.1. The residential SCDF is also shown in Figure A.1. Figure 2.1 clearly shows the relative cost impact on the different sectors of electric power outages of various outage durations. The numerical values are shown in Table B.2 to B.4.

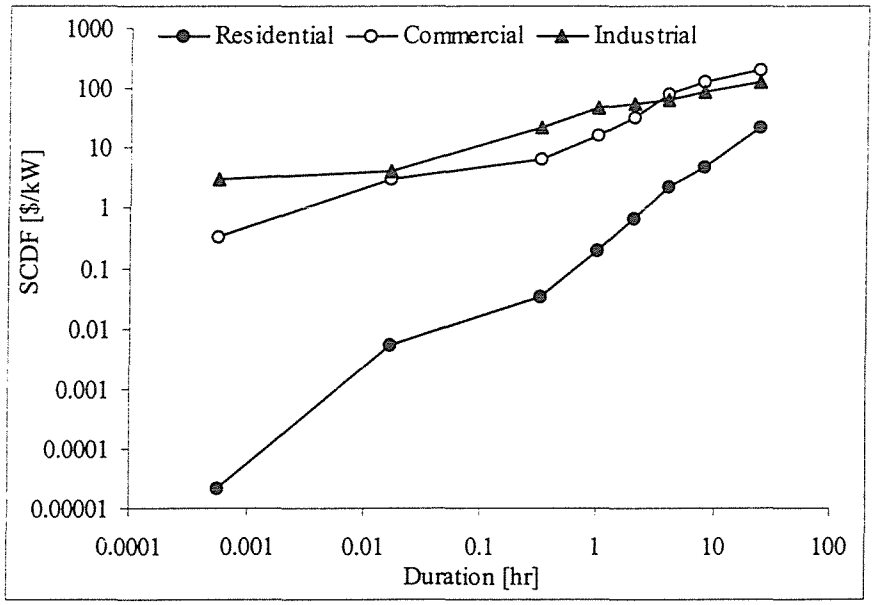

Figure 2.1 Annual Residential, Commercial and Industrial SCDF.

The annual CCDF is shown in Figure 2.2. The CCDF was obtained using the SCDF shown in Figure 2.1 and the relative sector annual energy consumption data shown in Table B.5. The numerical values for the annual CCDF shown in Figure 2.2 are given in Table B.6.

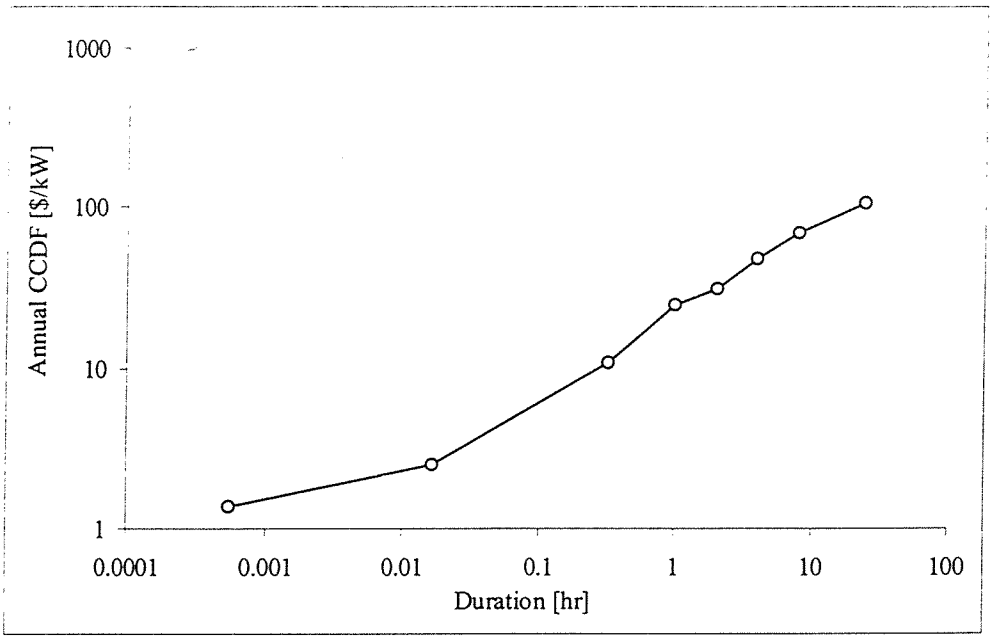

Figure 2.2 Annual CCDF ($/kW).

A CCDF in which the overall customer impact is measured in $/kWh of unserved energy can be obtained by dividing the $/kW values in Figure 2.2 by the corresponding outage durations. The CCDF is shown in Figure 2.3.

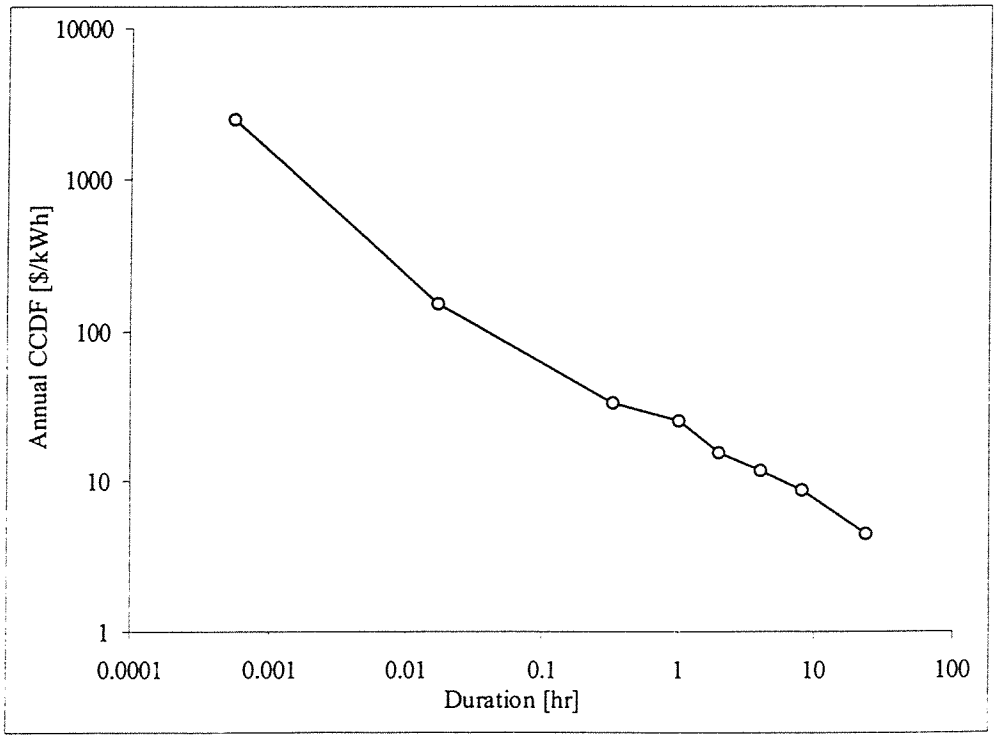

Figure 2.3 Annual CCDF ($/kWh).

The numerical values of the CCDF shown in Figure 2.3 are shown in Table 2.1. These values provide the best single representative set of outage cost values for the Manitoba system.

Table 2.1 Annual CCDF ($/kWh).

DURATION [hr]	CCDF [$/kWh]
0.000555556	2438.92
0.016666667	150.60
0.333333333	32.48
1	24.70
2	15.38
4	11.88
8	8.72
24	4.49

The values shown in Table 2.1 are usually referred to as interrupted energy assessment rates (IEAR). A single value system IEAR is usually utilized to assess the cost of unserved energy. This value is obtained by incorporating a probability distribution associated with outage durations. In order to illustrate this procedure consider the assumed simple outage duration distribution shown in Figure 2.4.

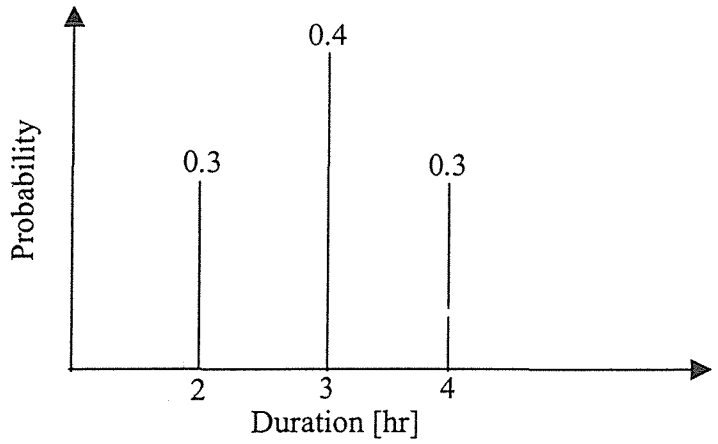

Figure 2.4 Outage duration distribution.

The system IEAR in this case is given by :

IEAR=0.3(15.386)+0.4(13.226)+0.3(11.88)=13.47 $/kWh

The single value system IEAR is obviously influenced by the assumed outage duration probability distribution. Given an assumed distribution, this value is the best estimate of the average cost of a kWh of unserved energy due to a random outage.

3. Monthly Analysis

The relative monthly energy consumptions for the assigned customer classes are shown in Table B.1 in the Appendix. The relative energy consumptions change from month to month and therefore the monthly sector customer damage functions will change. These data were used in conjunction with the ICDF to produce the monthly SCDF shown in Table C.1 and C.2. The SCDF were used in conjunction with the sector relative energy values shown in Table C.3 to produce the monthly CCDF. The set of monthly and annual CCDF ($/kW) are shown in Figure 3.1. The numerical values are shown in Table C.4.

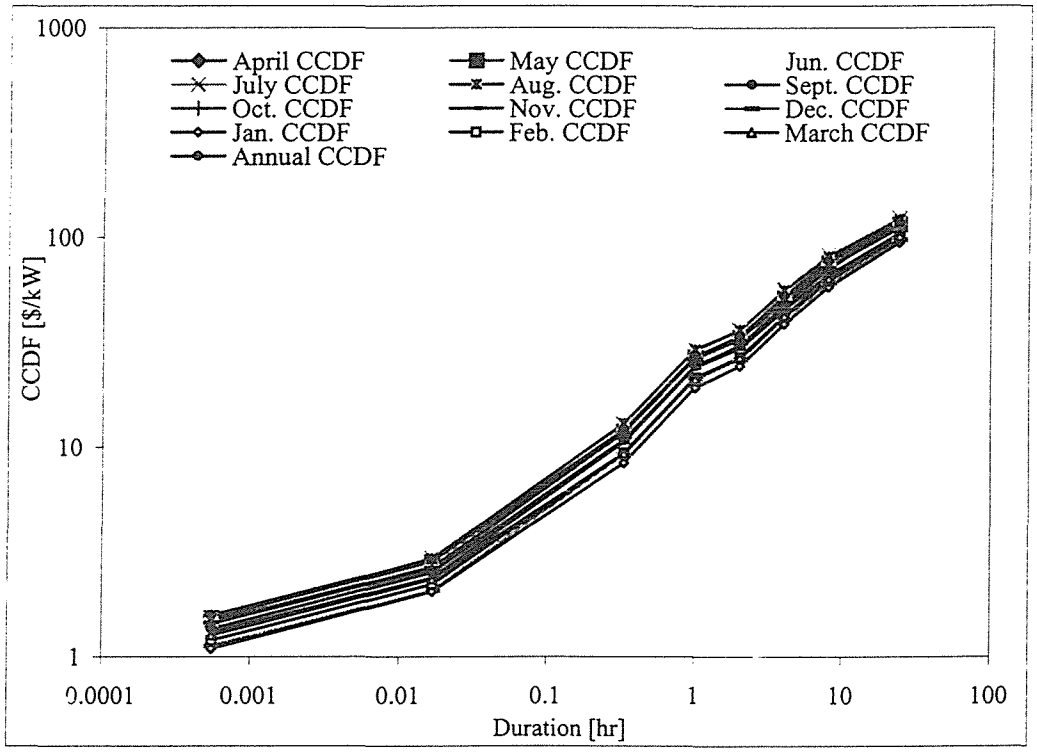

Figure 3.1 Annual and Monthly CCDF ($/kW).

It is difficult to see each individual monthly CCDF and to compare each one to the annual value using Figure 3.1. The individual monthly CCDF are compared with the annual CCDF in Figure C.1 to C.12. Figure 3.1 does, however, show the variation in the monthly values. Figure 3.2 shows the monthly and annual CCDF expressed in $/kWh.

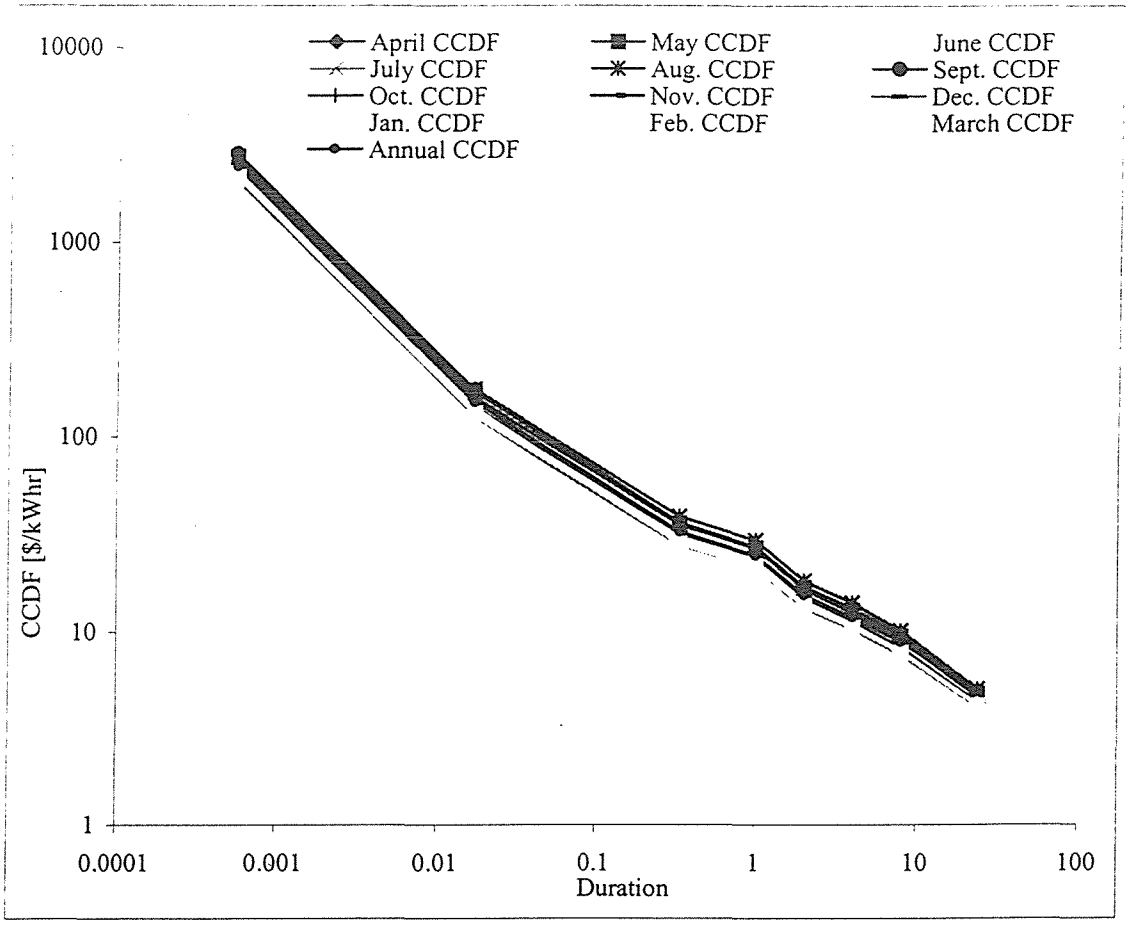

Figure 3.2 Annual and Monthly CCDF ($/kWh).

The corresponding individual monthly CCDF and the annual value are shown in Figures C.13 to C.24. The numerical values are shown in Table C.4.

Figure 3.2 and the numerical data in Table C.4 show that the interrupted energy assessment rate(s) will vary with time of the year as expressed by the monthly values. The obtained differences are due to the changing relative energy consumption over the year. There are other chronological factors associated with the various sector outage costs. These factors are discussed in the next section.

4. Chronological Customer Outage Cost Factors

The customer survey conducted by the University of Saskatchewan asked customers to estimate the variation interruption costs given that outage occurred at different times of the day, month and year. These questions were more definitive for the commercial and industrial customers than for residential customers. The following general conclusions can be drawn regarding residential customer outage costs. The respondents indicated that there are significant variations in the undesirability of various interruption scenarios when time of day, day of the week, season of the year and outage duration and frequency are considered. The data show that undesirability increases with increased frequency. Winter power failures are considered the most undesirable and summer outages being the least undesirable. Spring and fall are considered nearly equal. Weekday failures are considered to have worse consequences than weekend ones. Larger duration failures have greater undesirable consequences than shorter ones. Reference 1 contains further detail on the relative customer response to a range of questions on this issue.

The study described in Reference 2 asked a series of questions regarding cost variations in addition to questions on the worst time for an interruption to occur. Commercial customers indicated that interruption costs are relatively constant for the months of January to October and are highest in November and December. The variation from most costly to least costly is, however, only a few percentage points. Commercial customers indicated that Friday has the highest daily cost with Thursday and Saturday slightly lower. Monday, Tuesday, Wednesday and Sunday are almost the same, with Sunday the lowest. The results show that there is relatively little variation in cost over the hours in day.

Industrial customers indicated that there are only relatively small outage cost variations over the months in a year. This also applies to the days in a workweek with costs lower on Saturday and Sunday. Relatively little change in outage cost over the hours in a day was reported.

The customer responses noted above indicate that except for certain periods of the week there is relatively little change in the commercial and industrial interruption costs

with chronological variation. Although there is no corresponding outage cost data, it appears that there is greater variation in the residential interruption costs.

The relative contribution of the residential sector to the annual or monthly CCDF is much lower than that of the commercial and industrial sectors and therefore variations in the residential interruption costs will have a relatively small impact.

5. Special Considerations

The study described in Reference 1 asked the commercial and industrial customers a series of questions regarding outage cost mitigation given advance warning of an outage and knowledge about how long an outage could last if they were informed at the start of the interruption. In regard to the last question, 65.6% of the commercial customers indicated that they could not reduce the cost. The individual customer response indicated that knowledge about the outage duration would be of no benefit to 66% of the respondents. In the case of advance notice, 50% of the commercial customers said that they could not reduce costs by advance notice. The commercial customers who said that cost reduction was possible indicated that cost reductions of approximately 50% could be achieved with advance warning times of 5-16 hours.

In the case of industrial customers, 42% indicated that they could not reduce costs with advance warning. Those who indicated that cost saving could be achieved indicated that reductions of 47.3% could be achieved with early notification of 5-16 hours.

These factors may not be significant in the case of a random outage where advance notice is not possible and if knowledge of the expected duration is not available. They could, however, have relevance in the case of predictable rotating outages due to insufficient generating capability, or a major transmission facility outage which has the same system impact.

6. References

1. "Assessment of Reliability Worth in Electric Power Systems in Canada", R. Billinton, G. Waker, G. Tollefson, Final Report NSERC Grant STR00455005, March 1993.
2. "Electric Service Reliability Worth Evaluation for Government, Institutions and Office Buildings", R. Billinton, G. Waker, G. Tollefson, Final Report NSERC Grant STR00455005, March 1993.

Appendix A - Basic Data

The list of customer classes considered in this study together with the monthly and energy consumption was provided by Manitoba Hydro and is shown in Table A.1. The numerical values of the SIC customer CDF shown in Tables 1.1 to 1.3 and utilized in this study are shown in Figures A.1 to A.20. The individual SIC cost functions are designated as ICDF in these tables.

Table A.1. Manitoba customer class monthly and annual energy consumption.

Energy Sector	April Energy (GWh)	May Energy (GWh)	June Energy (GWh)	Jul. Energy (GWh)	Aug. Energy (GWh)	Sept. Energy (GWh)	Oct. Energy (GWh)	Nov. Energy (GWh)	Dec. Energy (GWh)	Jan. Energy (GWh)	Feb. Energy (GWh)	March Energy (GWh)	Total Energy (GWh)
RESIDENTIAL	330.0581	285.5204	274.3939	299.179396	303.821098	264.787278	345.81709	452.376604	621.2138	679.74477	505.7355	469.50837	**4832.16**
OFFICES	22.3005	22.85975	22.8971	25.14986	25.425616	21.926747	22.205853	26.271427	31.234477	34.186621	27.404283	26.971285	308.834
RESTAURANTS	11.9297	13.91177	14.37395	16.485353	16.331254	13.767428	12.88653	12.450562	13.39631	14.474287	12.510986	12.561057	165.079
RETAIL OUTLETS	30.74058	33.03286	34.05783	39.070069	39.180321	33.481506	32.406558	33.539012	38.023211	38.774045	32.900424	33.690406	418.897
GROCERY STORES	17.36739	19.17416	19.18409	21.425312	21.40922	19.053347	18.376406	17.803427	19.581778	20.855428	18.19357	19.441471	231.866
WAREHOUSES	15.65092	11.82309	13.26205	11.945511	12.553894	13.467933	16.833704	15.801172	18.402168	19.303171	17.28011	19.66062	185.984
SCHOOLS	21.40287	18.11289	16.83187	10.282271	11.471497	17.903236	22.104718	28.208291	34.269163	38.948811	30.560698	28.749057	278.845
COLLEGES	9.362836	9.945111	10.21507	11.188835	11.058133	9.801243	8.648258	9.30846	9.434594	10.276303	8.50667	8.871634	116.617
HEALTH FACILITIES	18.24511	18.08464	18.55226	20.20219	20.429024	17.813098	18.534381	21.427652	26.50875	29.077758	23.09877	22.907382	254.881
HOTELS & MOTELS	9.867904	10.83429	11.38922	13.606963	14.092325	11.204113	11.019349	12.250873	15.389333	16.789836	12.852158	12.502696	151.799
BULK APARTMENTS	25.25383	21.74111	21.27185	23.440275	23.63246	20.576336	25.448688	34.096987	45.459894	51.926785	37.875688	34.013181	364.737
GS HOUSING & SERVICES	6.260291	4.530341	4.32813	4.473218	4.414632	4.090211	4.842445	8.135167	12.677309	15.311317	10.936088	9.86562	89.8648
MISC COMMERCIAL	43.36802	36.71813	34.61705	37.416724	37.964503	37.069449	49.78995	58.97864	72.284024	78.353565	64.489716	61.573413	612.623
COMMERCIAL NON-BUILDING	9.721166	9.68198	9.718837	10.861558	10.874926	9.589235	10.571129	11.465873	13.385862	14.287807	11.546614	11.430931	133.136
BORDER SALES	2.437043	2.283947	2.13966	2.008494	2.012318	2.057786	2.682359	3.190552	4.182582	4.620729	3.63412	3.506136	34.7557
TOTAL COMMERCIAL	243.9082	232.734	232.839	247.556678	250.85017	231.801623	256.35035	292.928089	354.2294	387.18646	311.7898	305.74486	**3347.92**
AGRICULTURE	30.44645	27.35497	24.77362	25.68711	28.882624	28.101485	32.464963	37.519055	44.022118	48.033399	39.188803	39.6966	406.171
MINING	25.53356	24.23048	22.91338	22.804301	22.713239	22.813712	25.215929	26.291961	27.410224	28.101098	25.371742	26.661932	300.062
FOOD & BEVERAGE	29.10479	30.5842	30.17994	29.256689	27.795354	30.30393	31.560277	30.928076	32.27204	33.190695	30.307964	33.352679	368.837
PULP & PAPER	44.17939	43.92126	44.02553	45.137307	45.374506	41.488152	44.378866	43.571785	40.12739	47.330292	41.934228	46.989879	528.459
CHEMICALS & TREATMENT	80.92568	84.59977	84.0951	83.765825	75.723781	73.145839	76.141422	80.51214	77.244214	76.289637	70.179741	77.192526	939.816
PETROLEUM & OIL	83.07101	77.16329	82.80807	81.923668	86.328553	73.577669	84.312638	87.566677	89.824696	83.85093	78.109748	73.996951	982.534
PRIMARY METALS	181.3946	180.0812	166.1031	121.950886	151.479178	171.013091	179.79456	183.437538	189.53529	199.14268	181.72304	192.23361	2097.89
MISC INDUSTRIAL	40.25456	40.49842	42.04703	40.465072	40.339758	40.274796	40.542934	40.999569	40.679678	43.878509	40.064564	43.434631	493.48
INDUSTRIAL NON-BUILDING	2.5849	4.590842	5.497142	4.865236	5.324367	5.465687	7.215487	5.787144	7.107708	7.407157	4.671614	5.103176	65.6205
TOTAL INDUSTRIAL	517.495	513.0244	502.443	455.856059	483.961357	486.184369	521.62706	536.613896	548.2233	567.22438	511.55145	538.66195	**6182.87**

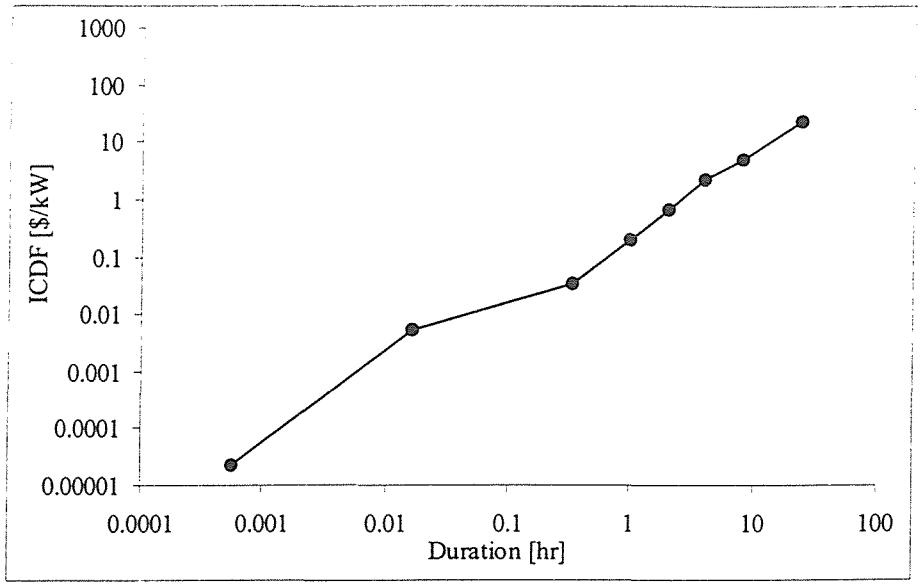

Figure A.1 Residential SCDF.

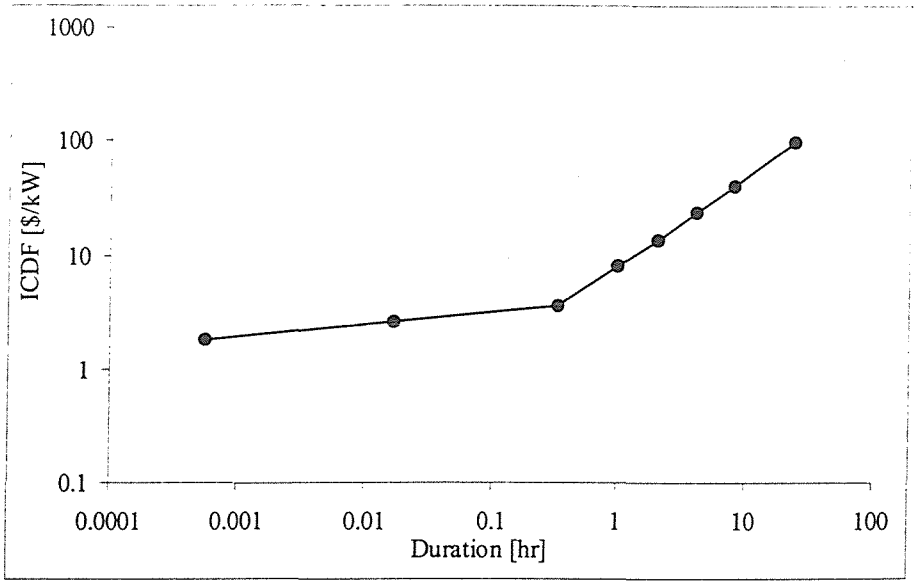

Figure A.2 Commercial customer CDF (Offices, GIO).

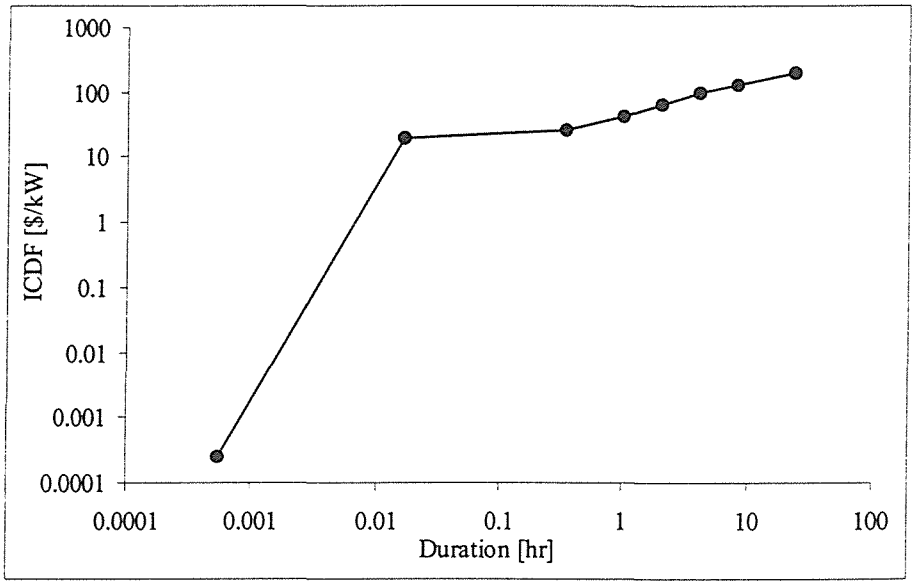

Figure A.3 Commercial customer CDF (Restaurants).

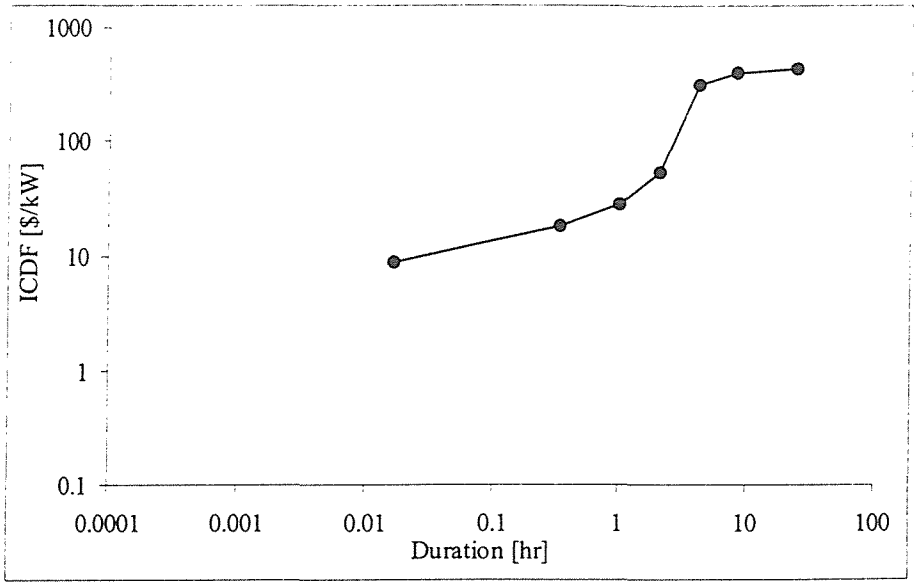

Figure A.4 Commercial customer CDF (Retail outlets).

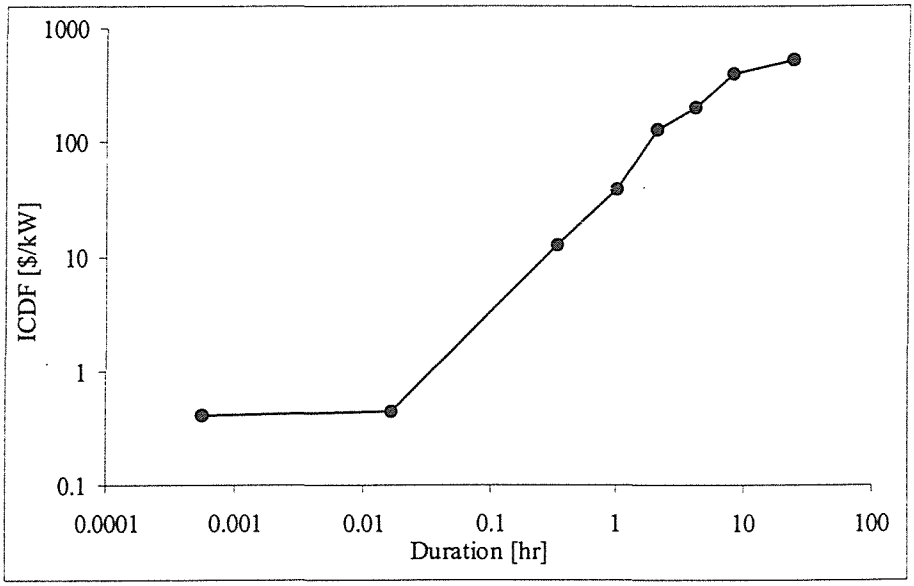

Figure A.5 Commercial customer CDF (Grocery stores).

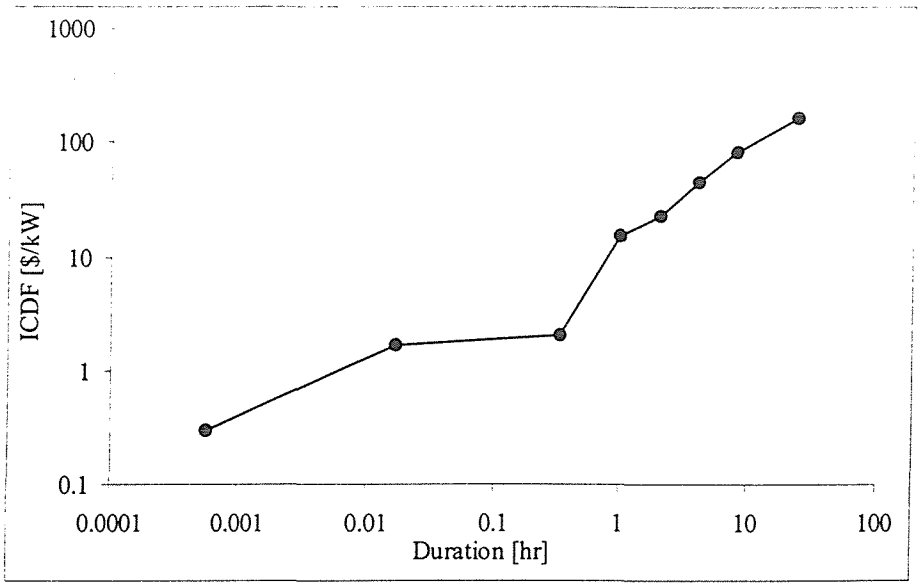

Figure A.6 Commercial customer CDF (Warehouses).

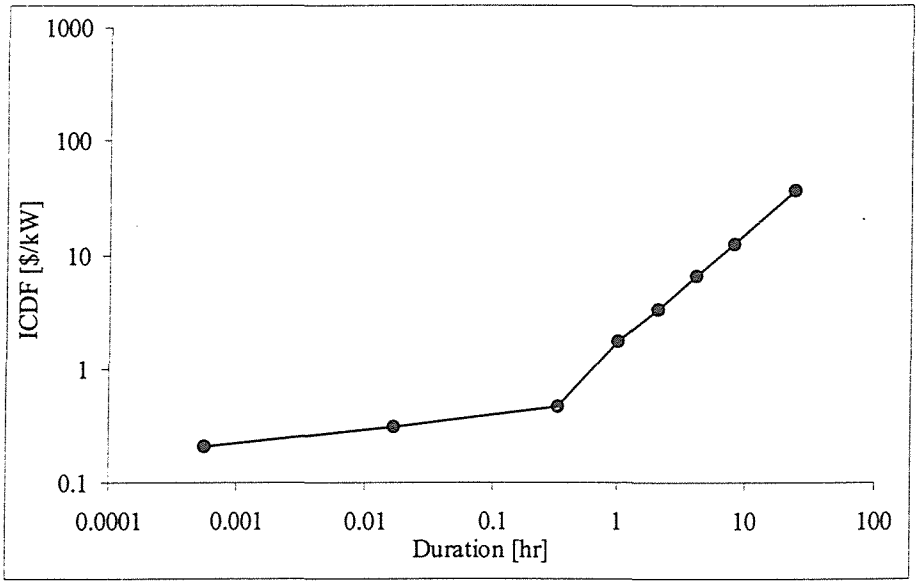

Figure A.7 Commercial customer CDF (Schools & Colleges).

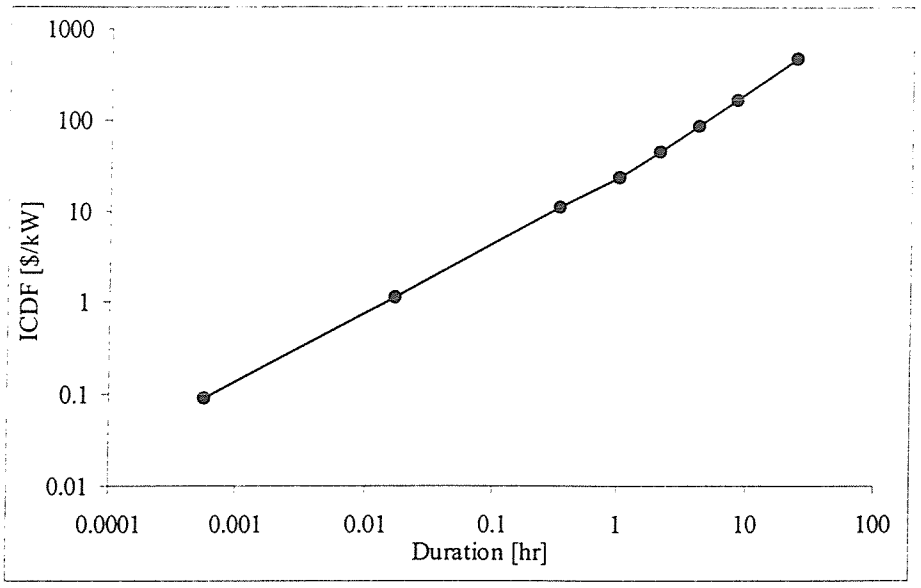

Figure A.8 Commercial customer CDF (Health facilities).

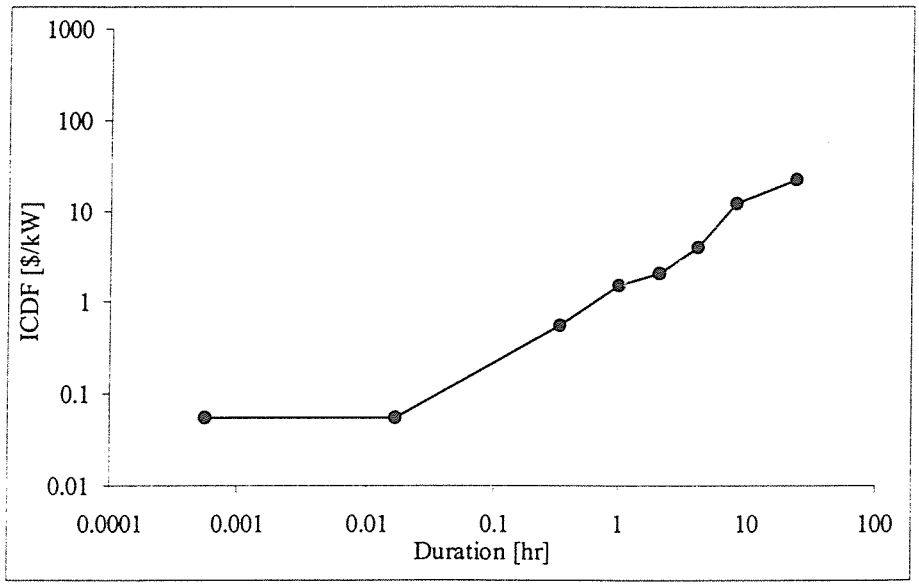

Figure A.9 Commercial customer CDF (Hotel and motels).

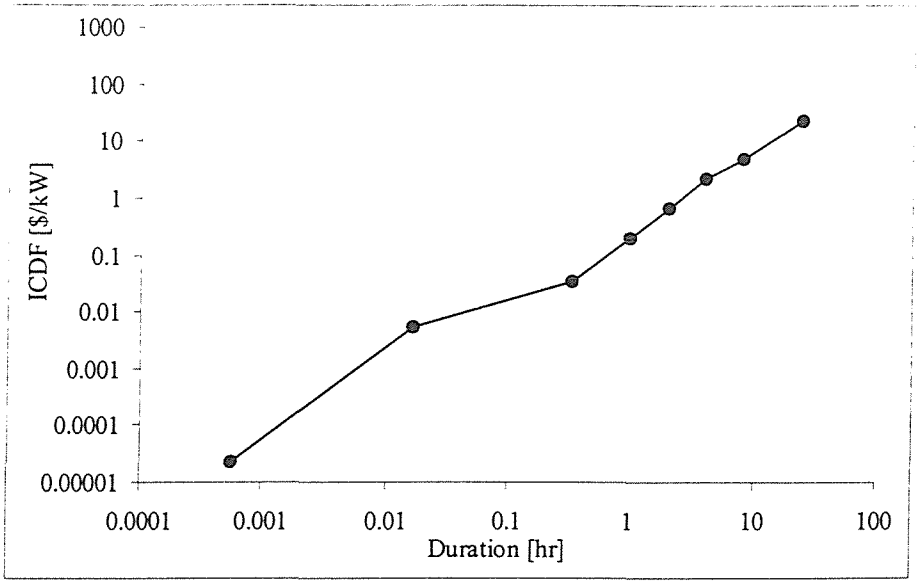

Figure A.10 Commercial customer CDF (Bulk apartments).

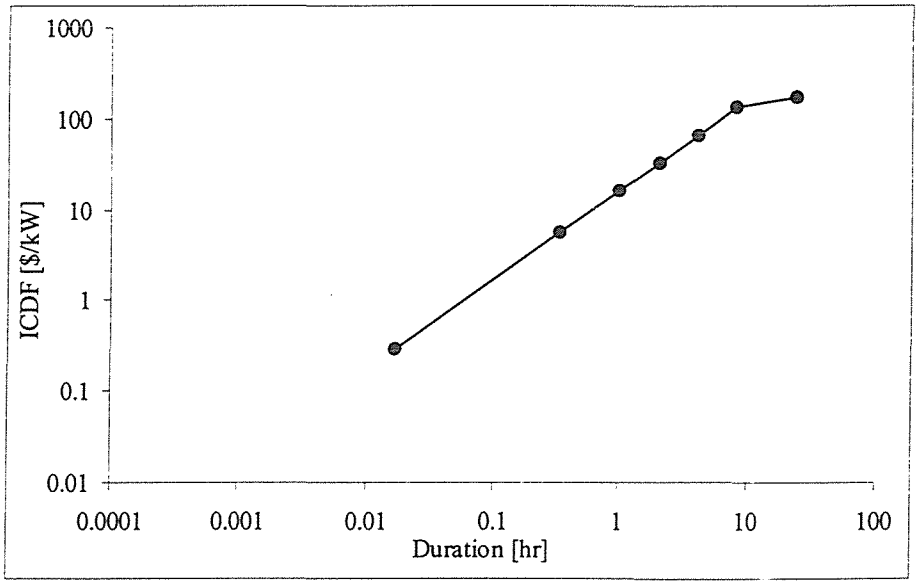

Figure A.11 Commercial customer CDF (GS housing & services).

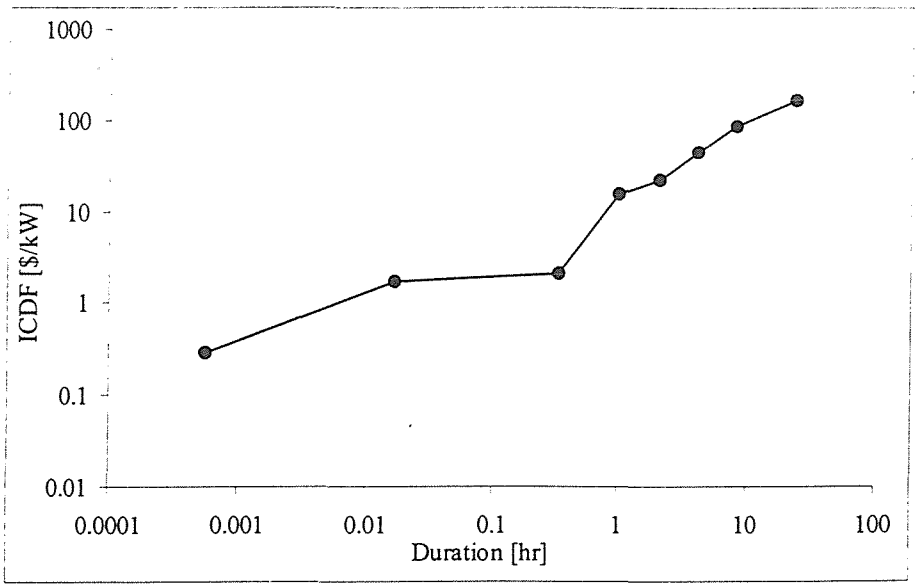

Figure A.12 Commercial customer CDF (MISC commercial, Commercial non-building & Border sales).

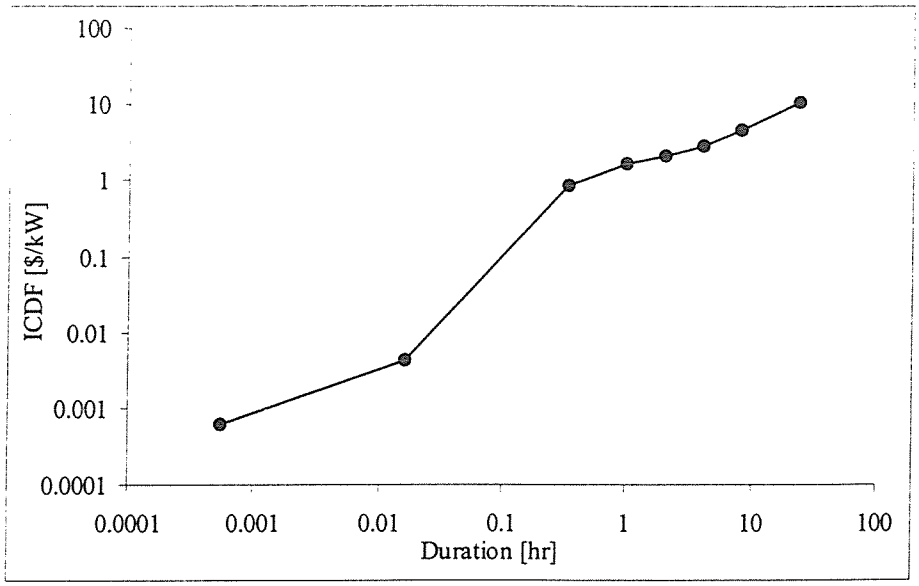

Figure A.13 Industrial customer CDF (Agricultural).

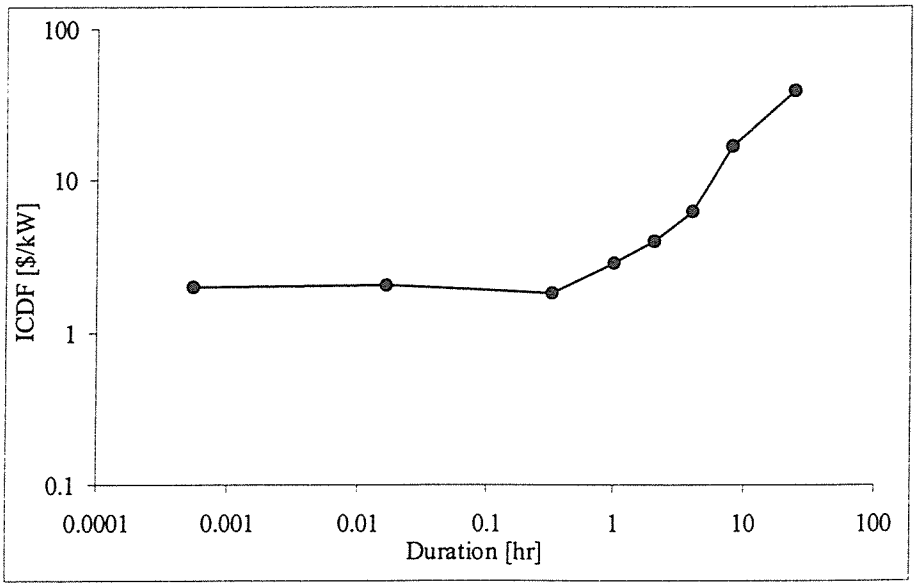

Figure A.14 Industrial customer CDF (Mining).

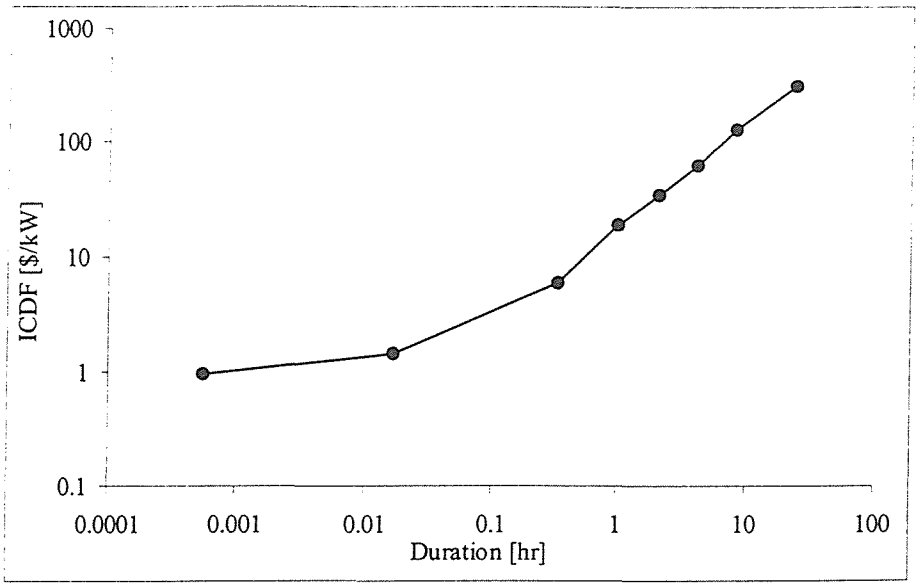

Figure A.15 Industrial customer CDF (Food and beverage).

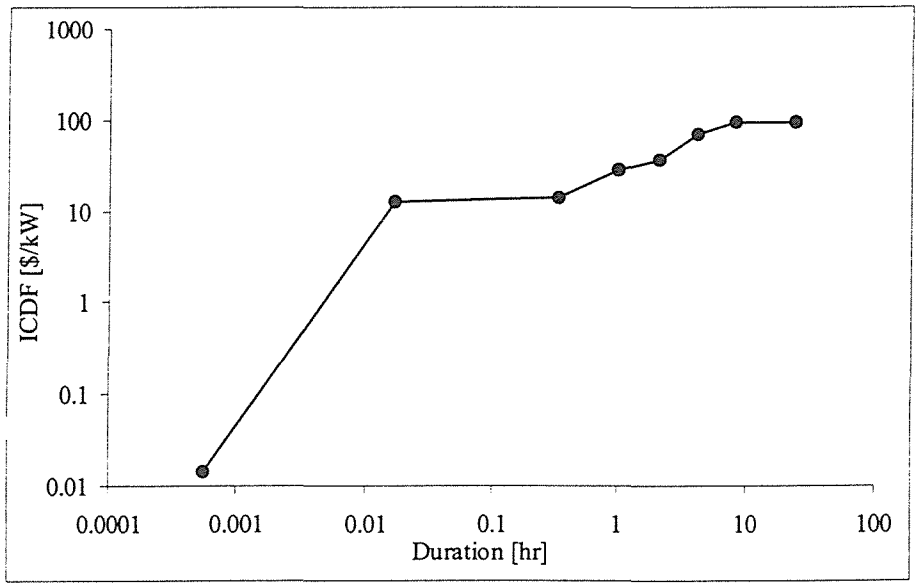

Figure A.16 Industrial customer CDF (Pulp and papers).

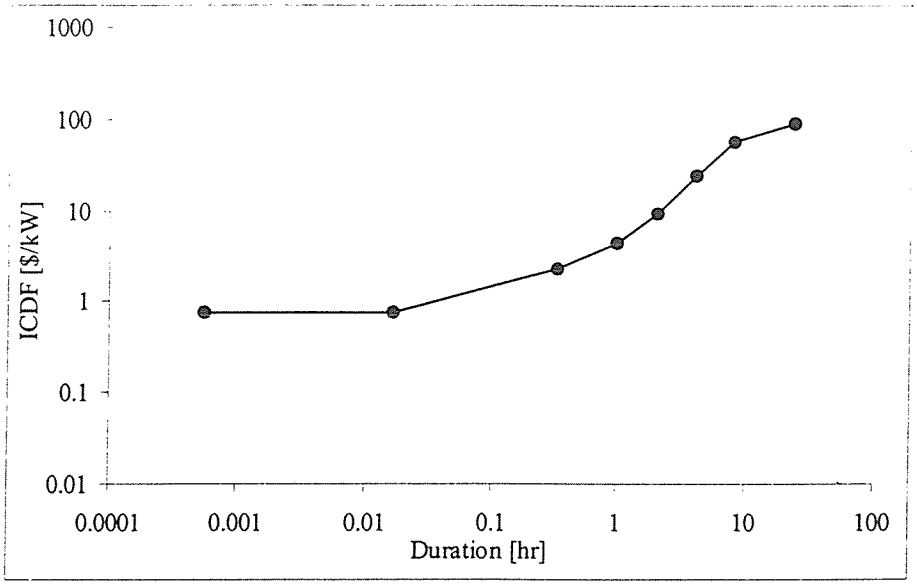

Figure A.17 Industrial customer CDF (Chemical and treatments).

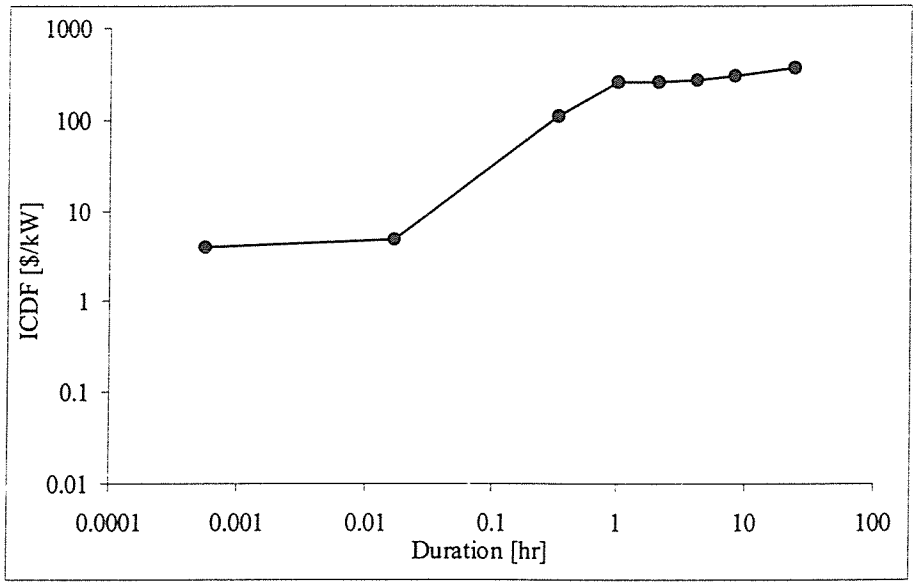

Figure A.18 Industrial customer CDF (Petroleum and oil).

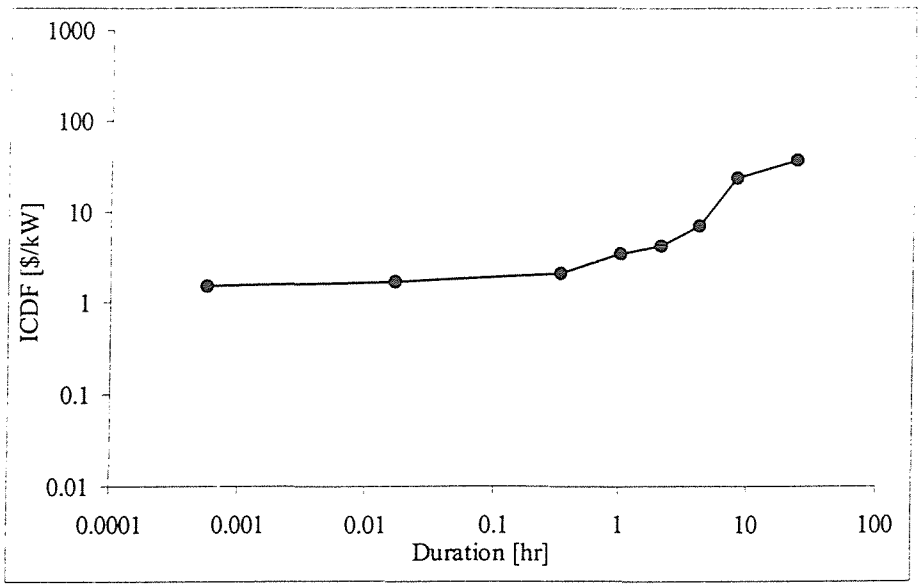

Figure A.19 Industrial customer CDF (Primary metals).

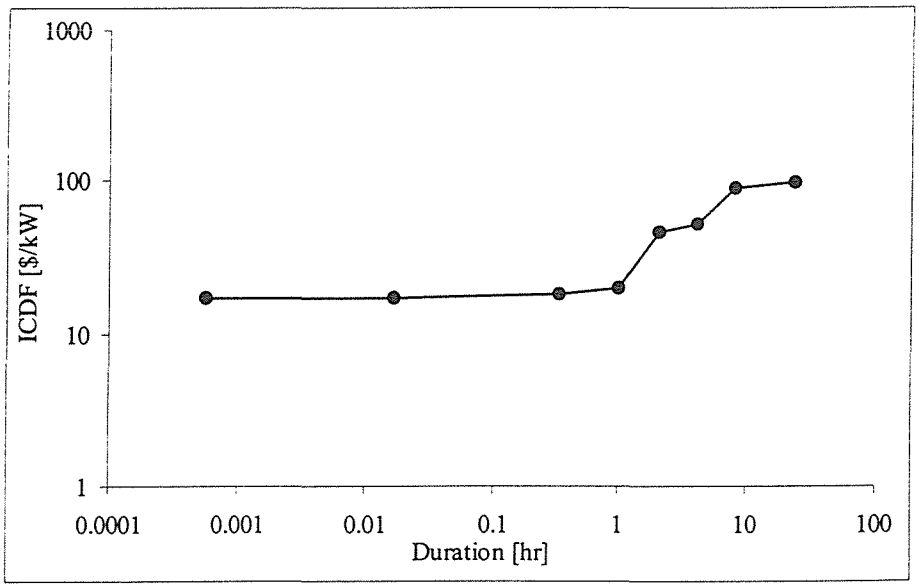

Figure A.20 Industrial customer CDF (Misc industrial & industrial non-building).

Appendix B - Annual Analysis Data

Table B.1. Relative monthly and annual energy consumptions.

Energy Sector	April Energy [%]	May Energy [%]	June Energy [%]	Jul. Energy [%]	Aug. Energy [%]	Sept. Energy [%]	Oct. Energy [%]	Nov. Energy [%]	Dec. Energy [%]	Jan. Energy [%]	Feb. Energy [%]	March Energy [%]	Total Energy [%]
RESIDENTIAL													**100**
OFFICES	9.143	9.8223	9.8339	10.159	10.136	9.4593	8.6623	8.9686	8.8176	8.8295	8.7893	8.8215	9.2246
RESTAURANTS	4.8911	5.9775	6.1733	6.6592	6.5104	5.9393	5.0269	4.2504	3.7818	3.7383	4.0126	4.1083	4.93084
RETAIL OUTLETS	12.603	14.193	14.627	15.782	15.619	14.444	12.642	11.45	10.734	10.014	10.552	11.019	12.5122
GROCERY STORES	7.1205	8.2387	8.2392	8.6547	8.5347	8.2197	7.1685	6.0777	5.528	5.3864	5.8352	6.3587	6.9256
WAREHOUSES	6.4167	5.0801	5.6958	4.8254	5.0045	5.8101	6.5667	5.3942	5.195	4.9855	5.5422	6.4304	5.55522
SCHOOLS	8.775	7.7827	7.229	4.1535	4.573	7.7235	8.6229	9.6298	9.6743	10.059	9.8017	9.403	8.32897
COLLEGES	3.8387	4.2732	4.3872	4.5197	4.4083	4.2283	3.3736	3.1777	2.6634	2.6541	2.7283	2.9016	3.4832
HEALTH FACILITIES	7.4803	7.7705	7.9678	8.1606	8.1439	7.6846	7.2301	7.315	7.4835	7.51	7.4084	7.4923	7.6131
HOTELS & MOTELS	4.0457	4.6552	4.8915	5.4965	5.6178	4.8335	4.2986	4.1822	4.3445	4.3364	4.1221	4.0893	4.5341
BULK APARTMENTS	10.354	9.3416	9.1359	9.4686	9.4209	8.8767	9.9273	11.64	12.833	13.411	12.148	11.125	10.894
GS HOUSING & SERVICES	2.5667	1.9466	1.8589	1.8069	1.7599	1.7645	1.889	2.7772	3.5788	3.9545	3.5075	3.2267	2.68419
MISC COMMERCIAL	17.78	15.777	14.867	15.114	15.134	15.992	19.423	20.134	20.406	20.237	20.684	20.139	18.2986
COMMERCIAL NON-BUILDING	3.9856	4.1601	4.1741	4.3875	4.3352	4.1368	4.1237	3.9142	3.7789	3.6902	3.7033	3.7387	3.976678
BORDER SALES	0.9992	0.9814	0.9189	0.8113	0.8022	0.8877	1.0464	1.0892	1.1808	1.1934	1.1656	1.1468	1.03817
TOTAL COM. (%)	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
AGRICULTURE	5.8834	5.3321	4.9306	5.6349	5.968	5.78	6.2238	6.9918	8.03	8.4681	7.6608	7.3695	6.56930
MINING	4.9341	4.7231	4.5604	5.0025	4.6932	4.6924	4.8341	4.8996	4.9998	4.9541	4.9598	4.9497	4.853112
FOOD & BEVERAGE	5.6242	5.9615	6.0066	6.418	5.7433	6.233	6.0504	5.7636	5.8867	5.8514	5.9247	6.1918	5.965469
PULP & PAPER	8.5372	8.5612	8.7623	9.9017	9.3756	8.5334	8.5078	8.1198	7.3195	8.3442	8.1975	8.7234	8.54718
CHEMICALS & TREATMENT	15.638	16.49	16.737	18.375	15.647	15.045	14.597	15.004	14.09	13.45	13.719	14.33	15.2003
PETROLEUM & OIL	16.053	15.041	16.481	17.971	17.838	15.134	16.163	16.318	16.385	14.783	15.269	13.737	15.8912
PRIMARY METALS	35.052	35.102	33.059	26.752	31.3	35.175	34.468	34.184	34.573	35.108	35.524	35.687	33.9306
MISC INDUSTRIAL	7.7787	7.8941	8.3685	8.8767	8.3353	8.2839	7.7724	7.6404	7.4203	7.7357	7.832	8.0634	7.981408
INDUSTRIAL NON-BUILDING	0.4995	0.8949	1.0941	1.0673	1.1002	1.1242	1.3833	1.0785	1.2965	1.3059	0.9132	0.9474	1.06132
TOTAL INDUSTRIAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table B.2. Annual Residential SCDF

DURATION	hours	SCDF
2 sec.	0.000555556	2.2E-05
1 min.	0.016666667	0.0052
20 min.	0.333333333	0.0336
1 hr.	1	0.1966
2 hr.	2	0.6565
4 hr.	4	2.192
8 hr.	8	4.838
24 hr.	24	22.07

Table B.3. Annual Commercial SCDF.

DURATION	hours	SCDF
2 sec.	0.000555556	0.315
1 min.	0.016666667	2.94
20 min.	0.333333333	6.361
1 hr.	1	15.90
2 hr.	2	31.29
4 hr.	4	81.17
8 hr.	8	130.10
24 hr.	24	204.50

Table B.4. Annual industrial SCDF.

DURATION	hours	SCDF
2 sec.	0.000555556	2.976
1 min.	0.016666667	4.230
20 min.	0.333333333	21.681
1 hr.	1	48.63
2 hr.	2	54.027
4 hr.	4	64.72
8 hr.	8	87.846
24 hr.	24	122.68

Table B.5 Annual energy.

	GWhr	[%]
Residential	4832.157	33.643
commercial	3347.919	23.309
industrial	6182.866	43.047
Total energy for the year	14362.94	100

Table B.6. Annual CCDF [$/kW].

DURATION	**hours**	**CCDF [$/kW]**
2 sec.	0.000555556	1.355
1 min.	0.016666667	2.510
20 min.	0.333333333	10.827
1 hr.	1	24.709
2 hr.	2	30.772
4 hr.	4	47.522
8 hr.	8	69.770
24 hr.	24	107.906

Appendix C - Monthly Analysis Data

Table C.1. Monthly commercial SCDF [$/kW].

Hour	April SCDF	May SCDF	June SCDF	Jul. SCDF	Aug. SCDF	Sept. SCDF	Oct. SCDF	Nov. SCDF	Dec. SCDF	Jan. SCDF	Feb. SCDF	March SCDF
0.000555556	0.3169	0.3241	0.3227	0.3234	0.3235	0.3196	0.3127	0.3137	0.3081	0.3072	0.3106	0.3139
0.016666667	2.9516	3.2747	3.3463	3.5371	3.4952	3.2909	2.9962	2.7376	2.5796	2.5042	2.6194	2.687
0.333333333	6.3755	7.0397	7.1766	7.5703	7.4866	7.0565	6.3808	5.8884	5.6264	5.4867	5.6913	5.8654
1	15.983	16.863	17.046	17.684	17.542	16.957	16.155	15.177	14.722	14.453	14.936	15.332
2	31.544	33.822	34.146	35.516	35.196	33.938	31.737	29.461	28.39	27.853	28.9	29.905
4	81.749	88.397	89.848	94.479	93.634	89.164	82.143	76.155	73.101	70.695	73.48	76.045
8	131.06	140.39	142.23	148.72	147.47	141.38	131.63	122.69	118.42	115.24	119.43	123.48
24	205.5	215.66	218	225.5	224.05	216.77	206.39	195.92	191.28	187.64	192.78	197.91

Table C.2. Monthly industrial SCDF [$/kW].

Hour	April SCDF	May SCDF	June SCDF	Jul. SCDF	Aug. SCDF	Sept. SCDF	Oct. SCDF	Nov. SCDF	Dec. SCDF	Jan. SCDF	Feb. SCDF	March SCDF
0.000555556	2.873	2.925	3.065	3.134	3.079	3.026	3.011	2.94	2.945	2.938	2.916	2.909
0.016666667	4.127	4.175	4.349	4.565	4.447	4.275	4.263	4.144	4.051	4.159	4.124	4.172
0.333333333	21.73	20.75	22.43	24.24	23.92	20.95	21.99	22.02	21.99	20.44	20.91	19.39
1	48.88	46.45	50.32	54.57	53.88	46.81	49.35	49.53	49.48	45.68	46.86	43.17
2	54.05	51.83	55.92	60.51	59.44	52.31	54.76	54.78	54.67	50.94	52.08	48.52
4	64.73	62.61	66.99	72.4	70.63	63.01	65.44	65.3	64.84	61.18	62.38	58.99
8	87.67	86.07	90.77	96.78	93.99	86.42	88.57	88.12	87.35	83.63	84.95	81.92
24	122.2	120.7	126.4	134.1	129.6	121.2	123.6	122.9	122.2	117.2	119.1	115.6

Table C.3. Monthly relative energy consumptions for the Residential, Commercial and Industrial sectors.

Energy Sector	April Energy [%]	May Energy [%]	June Energy [%]	Jul. Energy [%]	Aug. Energy [%]	Sept. Energy [%]	Oct. Energy [%]	Nov. Energy [%]	Dec. Energy [%]	Jan. Energy [%]	Feb. Energy [%]	March Energy [%]
RESIDENTIAL	30.240	27.686	27.176	29.84058	29.2520	26.94286	30.772	35.2890	40.7709	41.5960	38.0516	35.733
COMMERCIAL	22.346	22.567	23.060	24.69166	24.1519	23.58648	22.811	22.8507	23.2484	23.6933	23.4591	23.269
INDUSTRIAL	47.413	49.746	49.76	45.46774	46.5960	49.470651	46.4165	41.8602	35.9805	34.7105	38.4892	40.996
Total	100	100	100	100	100	100	100	100	100	100	100	100

Table C.4. Monthly CCDF ($/kWh).

Hour	April **CCDF**	May **CCDF**	June **CCDF**	July **CCDF**	Aug. **CCDF**	Sept. **CCDF**	Oct. **CCDF**	Nov. **CCDF**	Dec. **CCDF**	Jan. **CCDF**	Feb. **CCDF**	March **CCDF**
0.000555556	2579.2	2750.7	2879	2708.4	2723.3	2830	2644.2	2344.6	2036.2	1966.4	2151.6	2278.3
0.016666667	157.06	169.05	176.23	177.04	175.07	173.54	159.84	141.73	123.56	122.34	132.22	140.24
0.333333333	35.211	35.763	38.477	38.707	38.897	36.109	35.022	31.729	27.7	25.227	28.188	27.98
1	26.808	26.969	29.026	29.239	29.4	27.208	26.654	24.27	21.307	19.361	21.616	21.336
2	16.438	16.798	17.939	18.24	18.194	17.03	16.431	14.947	13.268	12.277	13.537	13.543
4	12.405	12.926	13.663	14.225	14.042	13.198	12.447	11.377	10.304	9.7246	10.521	10.665
8	9.0397	9.4802	9.9108	10.271	10.103	9.6753	9.0781	8.3286	7.6164	7.2931	7.8195	8.0058
24	4.6063	4.7847	4.9647	5.1339	5.0404	4.8772	4.6357	4.3333	4.0602	3.9295	4.1437	4.2219

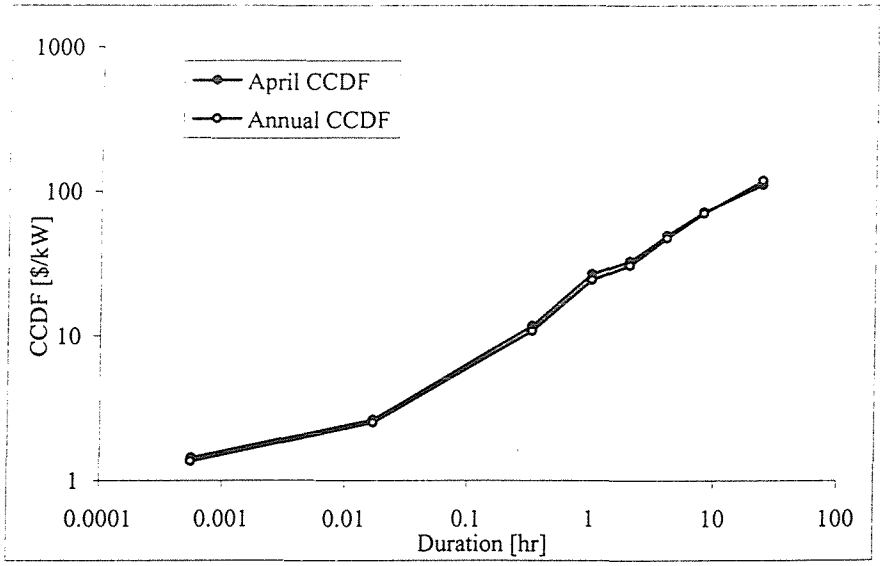

Figure C.1 Annual and April CCDF ($/kW).

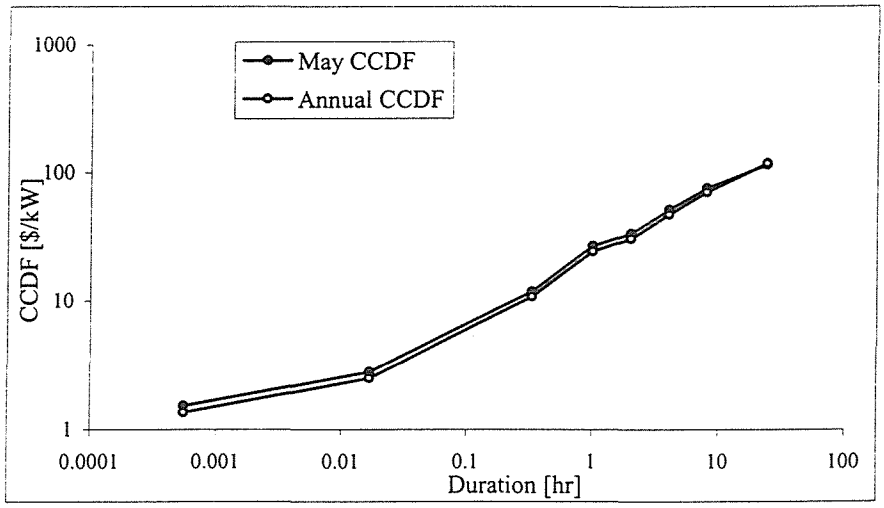

Figure C.2 Annual and May CCDF ($/kW).

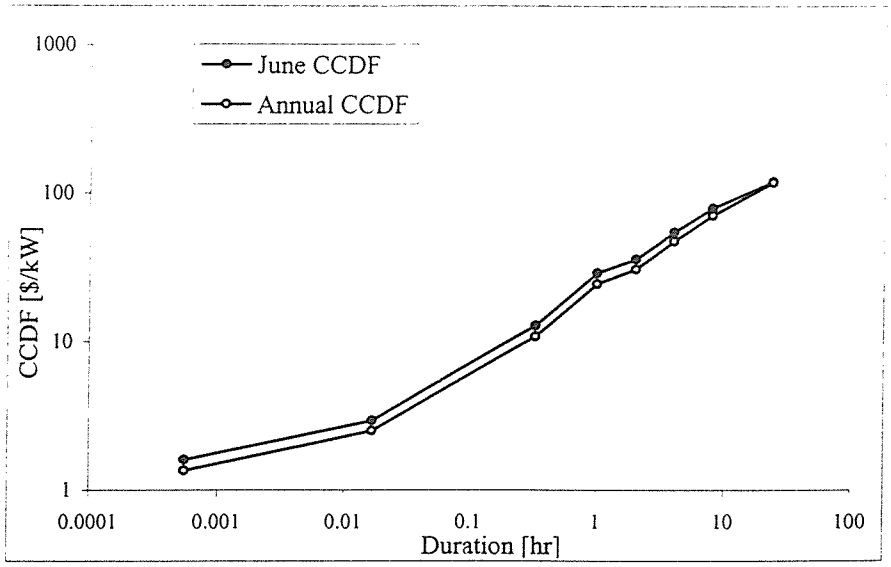

Figure C.3 Annual and June CCDF ($/kW).

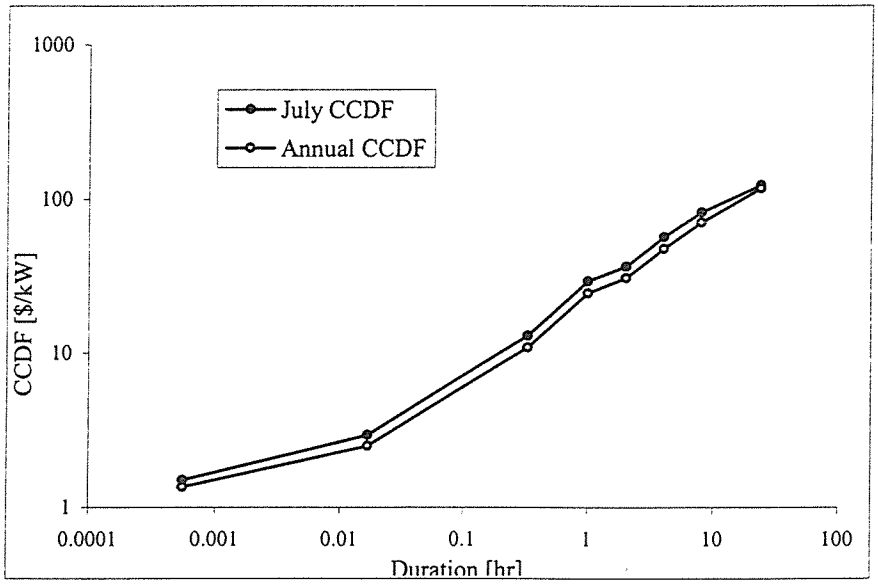

Figure C.4 Annual and July CCDF ($/kW).

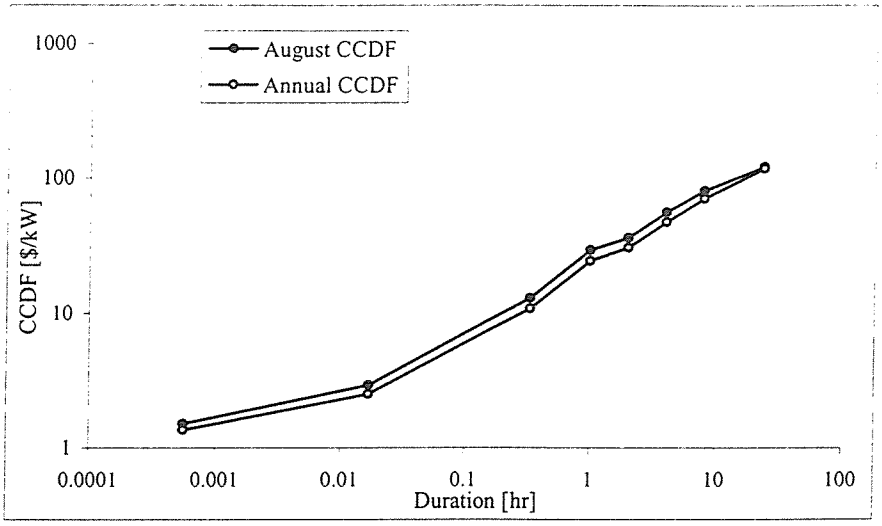

Figure C.5 Annual and August CCDF ($/kW).

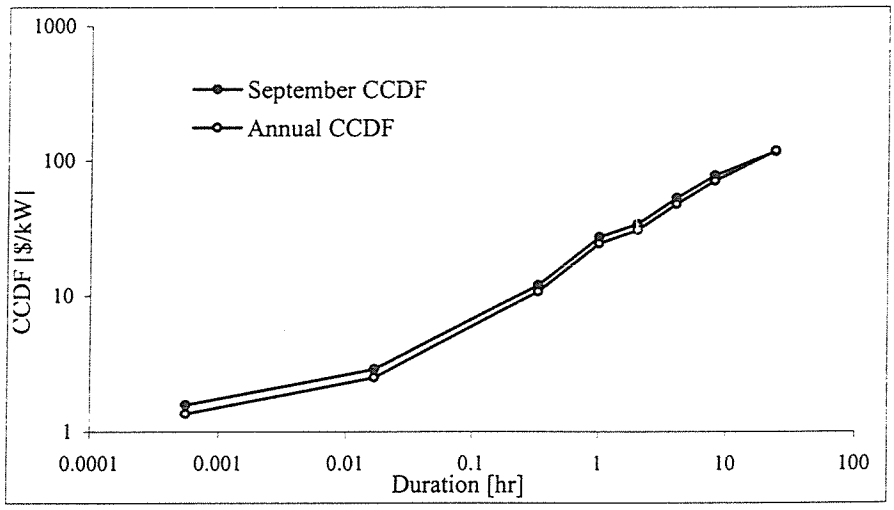

Figure C.6 Annual and September CCDF ($/kW).

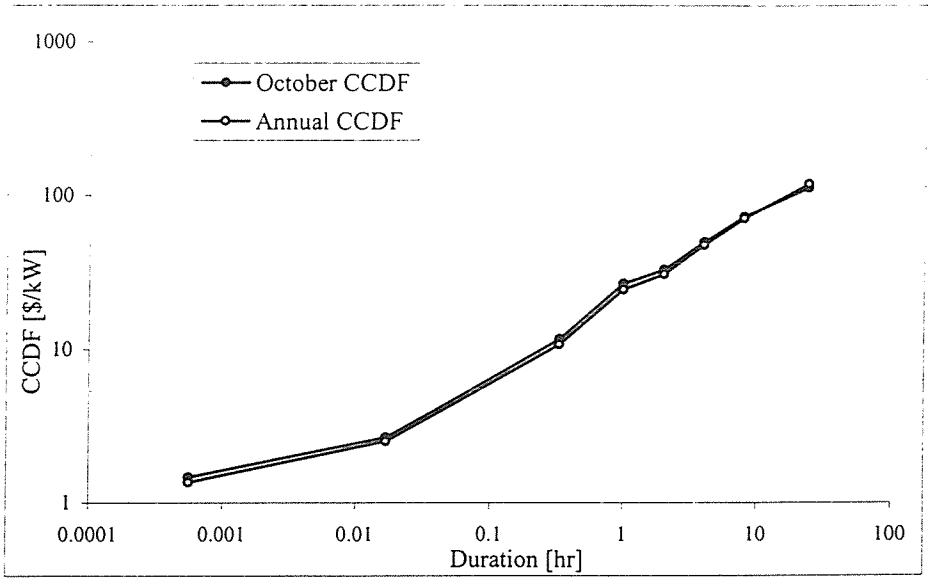

Figure C.7 Annual and October CCDF ($/kW).

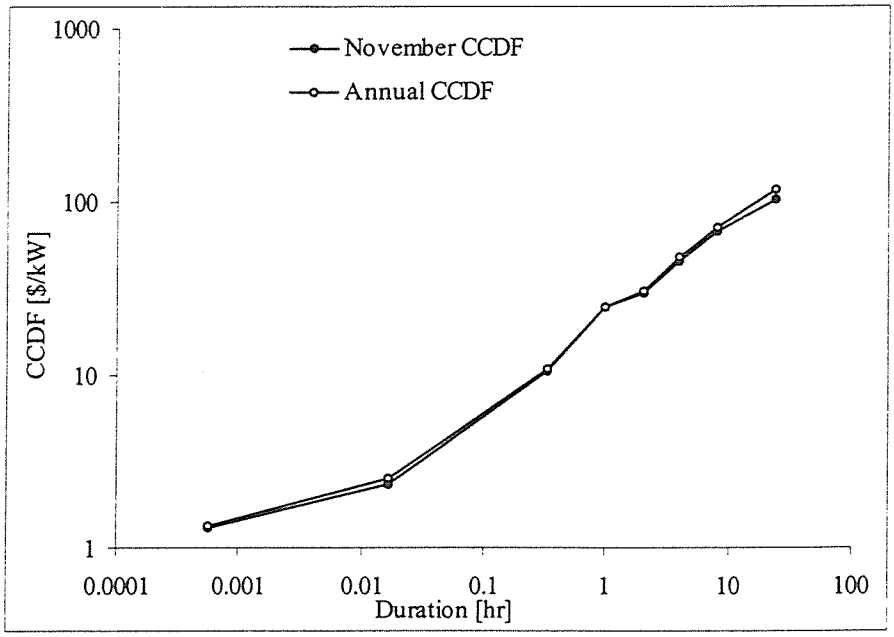

Figure C.8 Annual and November CCDF ($/kW).

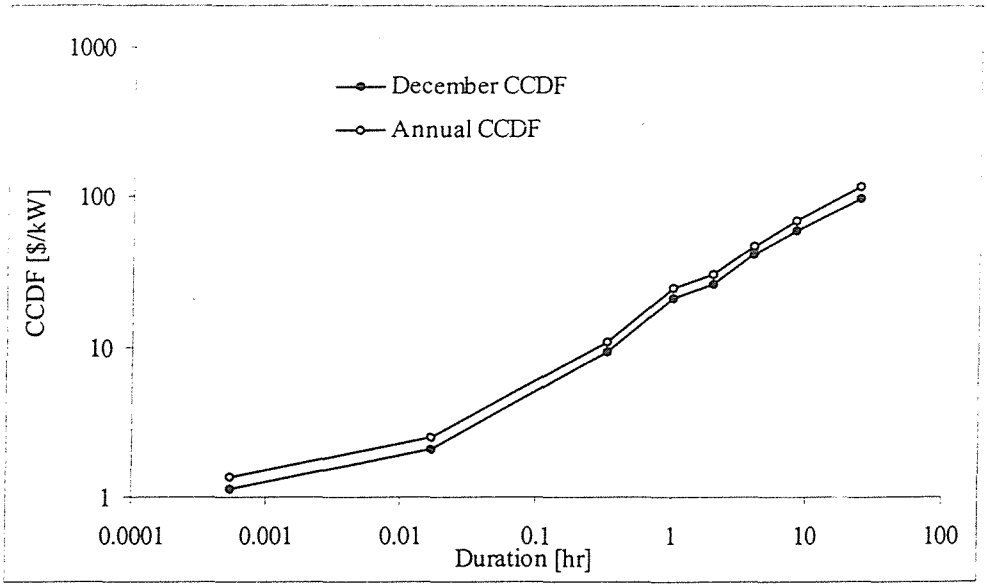

Figure C.9 Annual and December CCDF ($/kW).

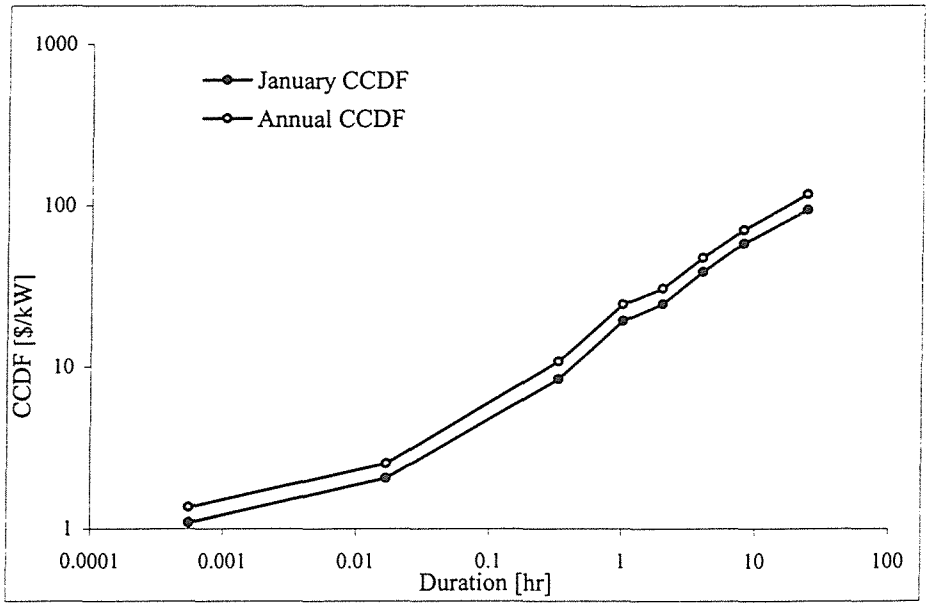

Figure C.10 Annual and January CCDF ($/kW).

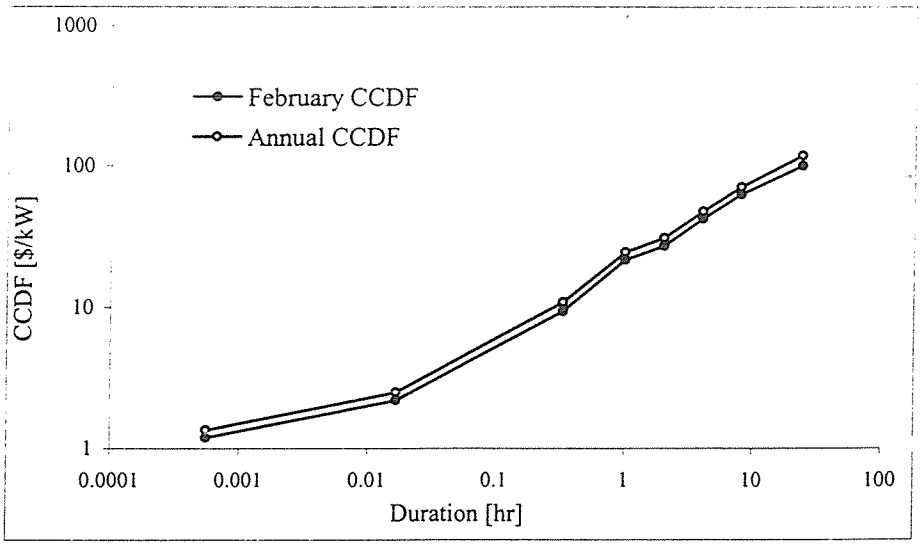

Figure C.11 Annual and February CCDF ($/kW).

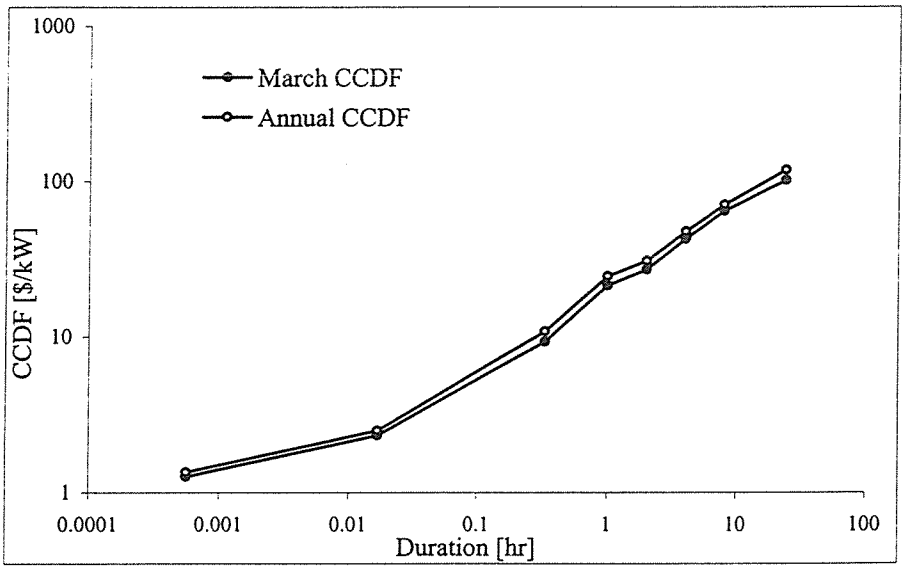

Figure C.12 Annual and March CCDF ($/kW).

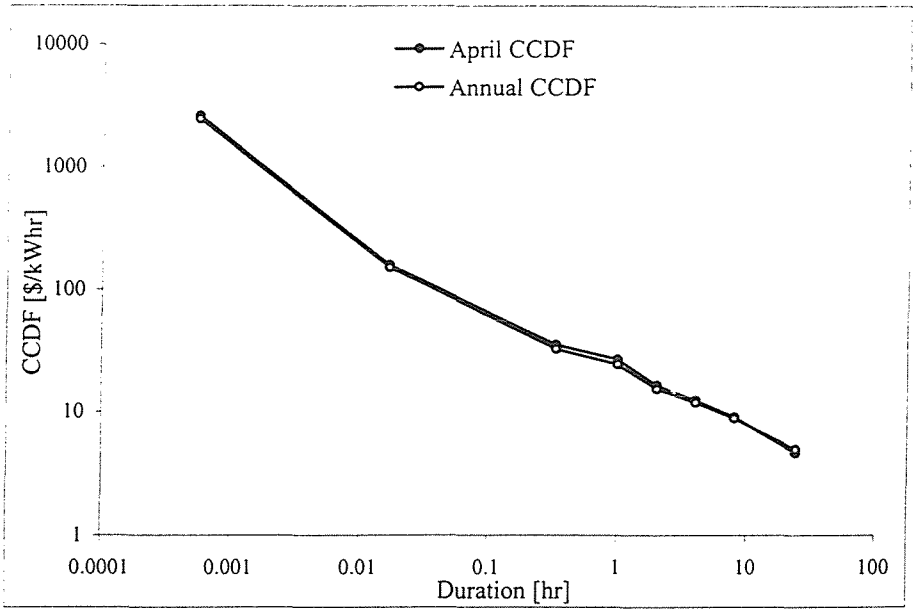

Figure C.13 Annual and April CCDF ($/kWh).

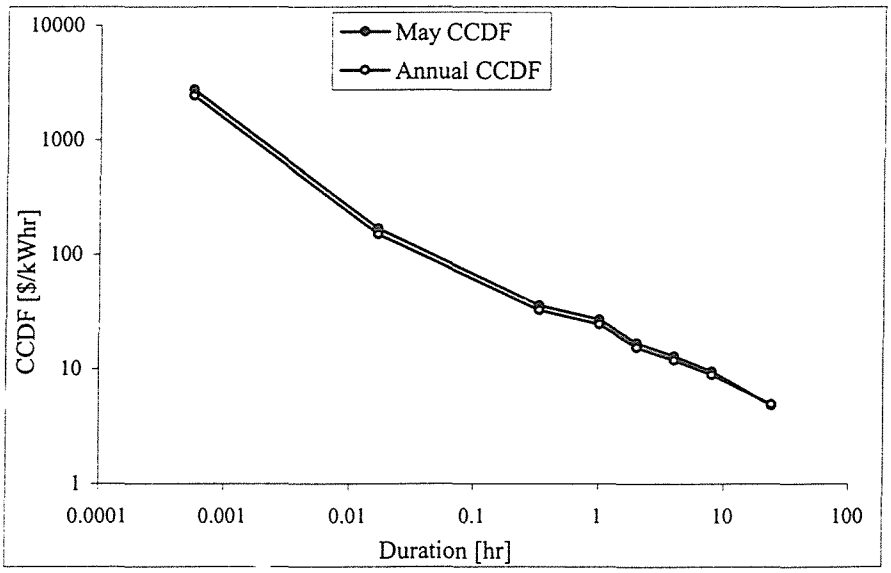

Figure C.14 Annual and May CCDF ($/kWh).

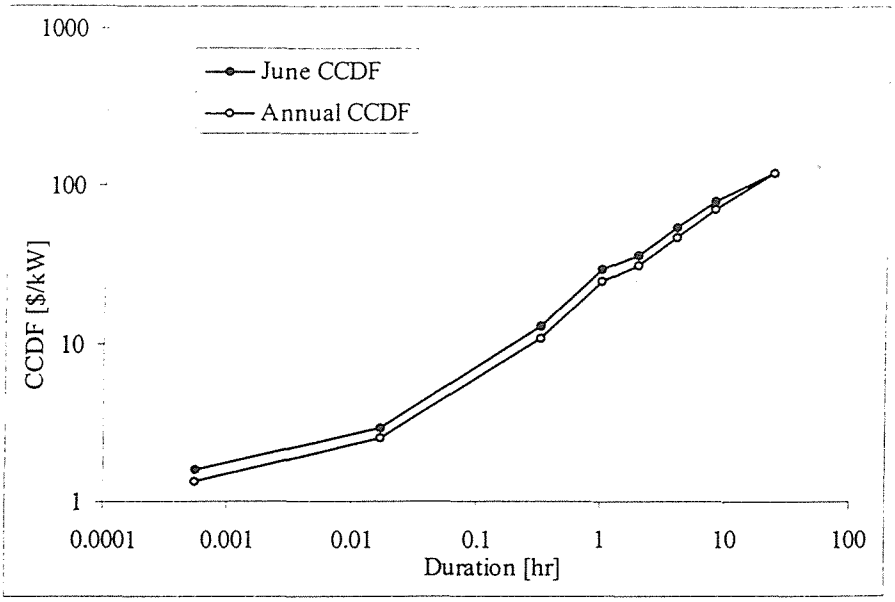

Figure C.15 Annual and June CCDF ($/kWh).

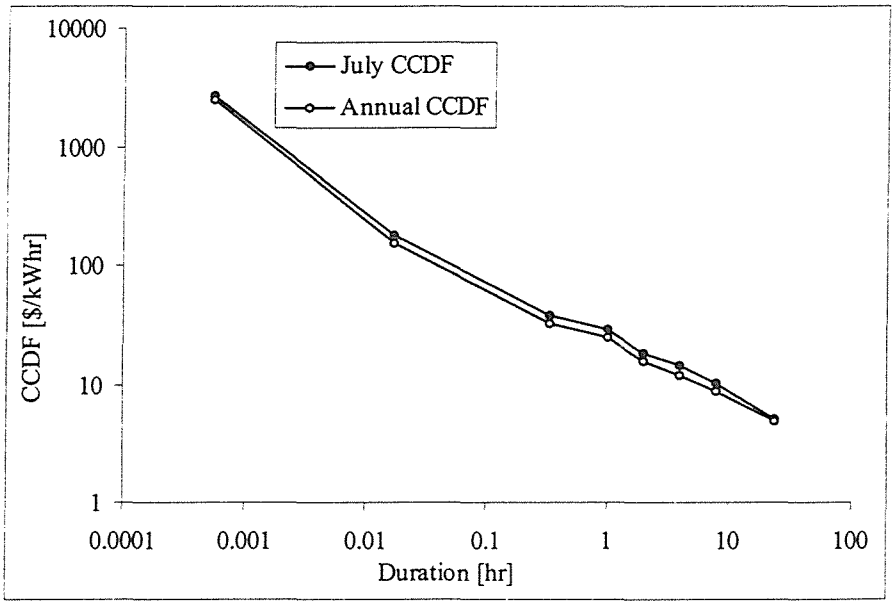

Figure C.16 Annual and July CCDF ($/kWh).

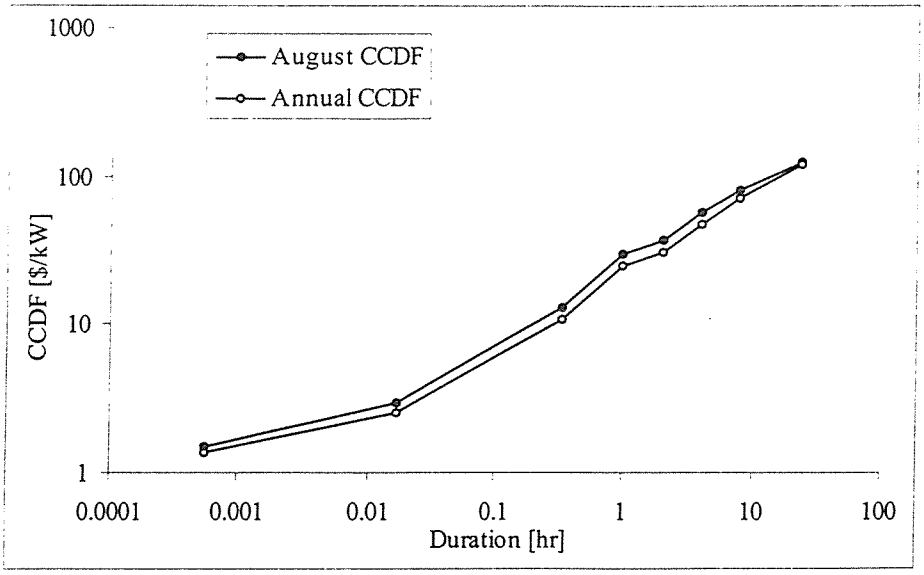

Figure C.17 Annual and August CCDF ($/kWh).

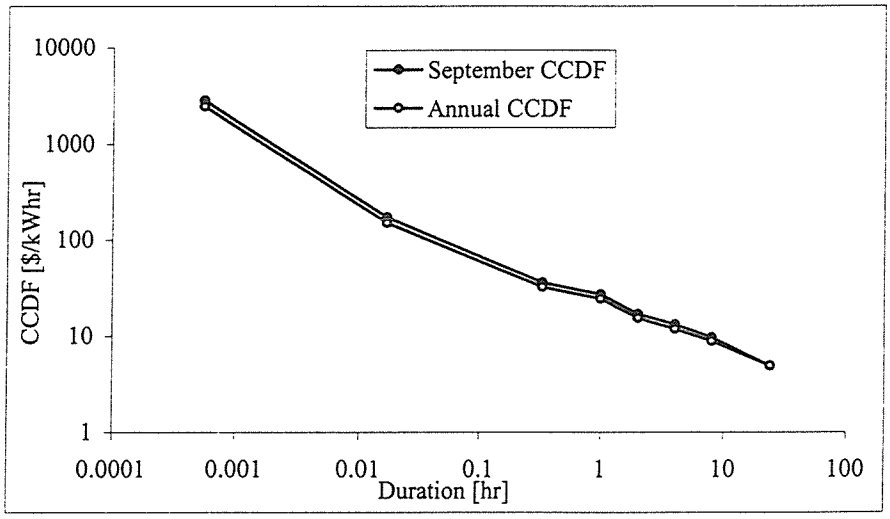

Figure C.18 Annual and September CCDF ($/kWh).

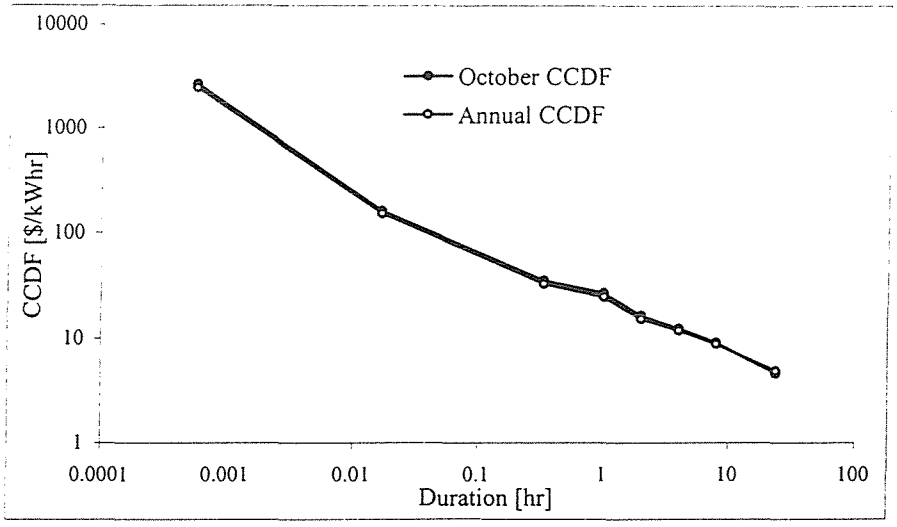

Figure C.19 Annual and October CCDF ($/kWh).

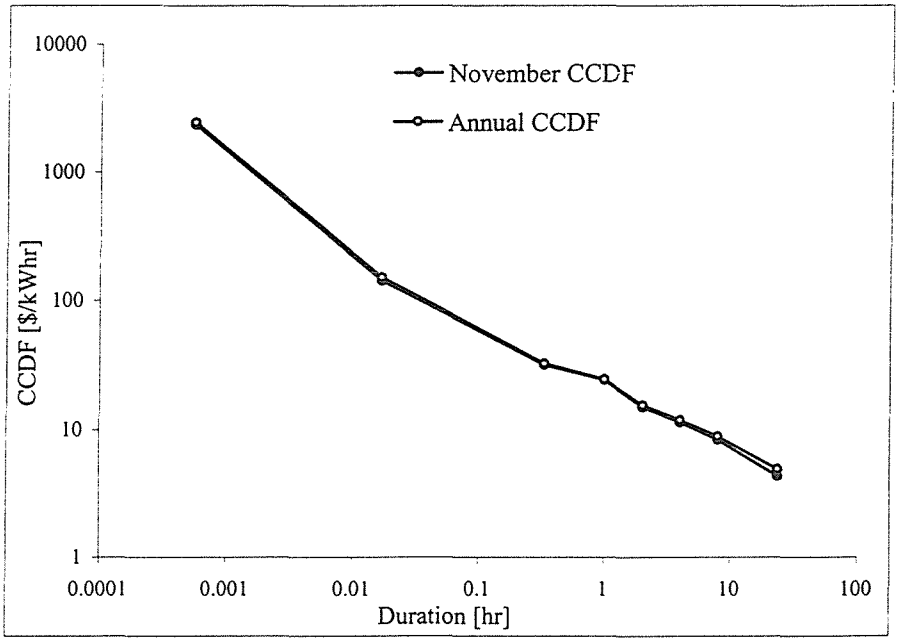

Figure C.20 Annual and November CCDF ($/kWh).

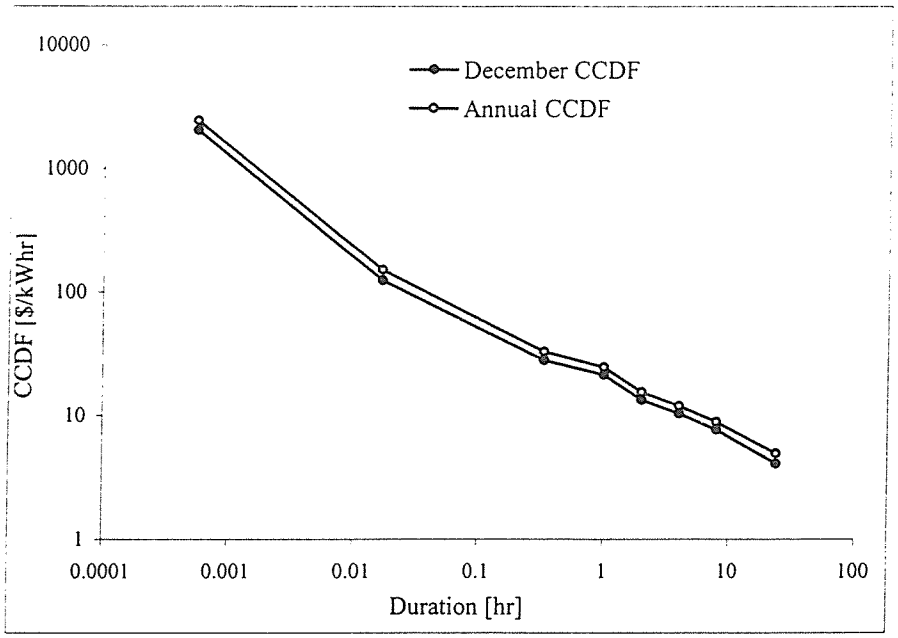

Figure C.21 Annual and December CCDF ($/kWh).

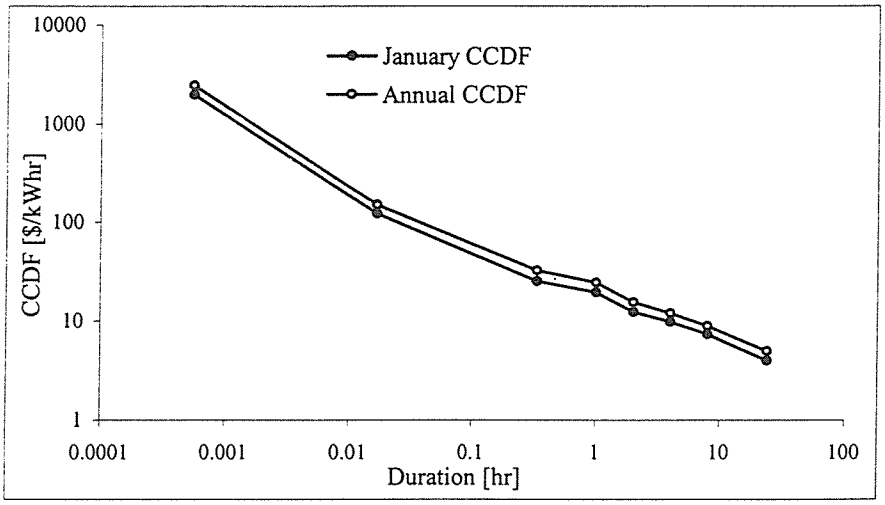

Figure C.22 Annual and January CCDF ($/kWh).

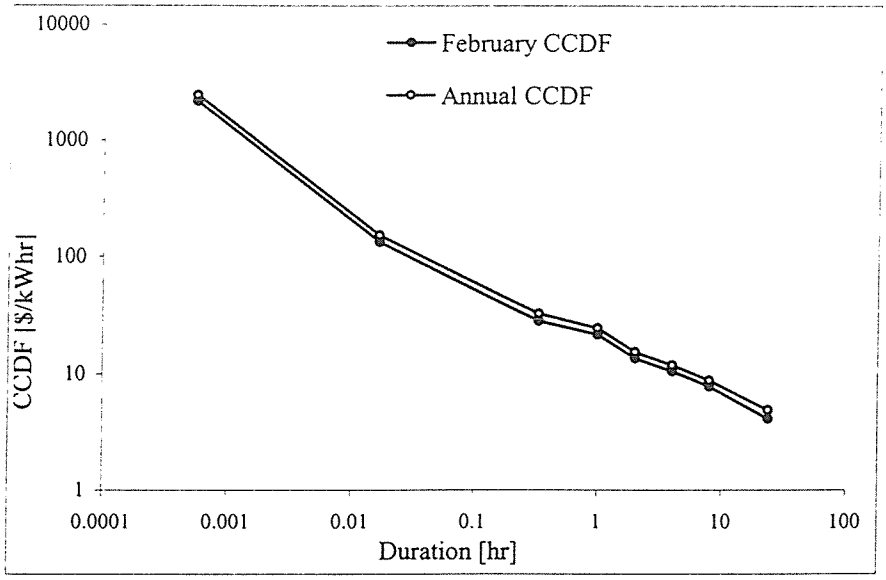

Figure C.23 Annual and February CCDF ($/kWh).

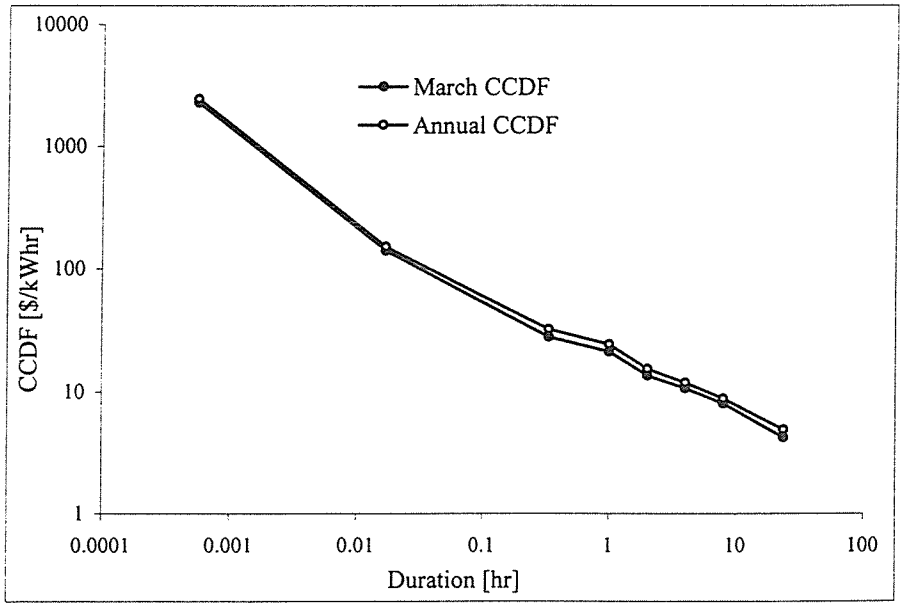

Figure C.24 Annual and March CCDF ($/kWh).