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Determination of Data for Reliability Analysis of a Transmission System in Sulaimani-Erbil Network

[1]Ghamgeen Izat Rashed, [2]Asso R. Majeed and [1]S.J.Cheng
[1]Department of Electrical Power Engineering,
Huazhong University of Science and Technology Wuhan, 430074, China
[2]Department of Electrical Engineering, Sulaimanyia University, Iraq

Abstract: The research presented in this study deals with the data collection and analysis of 132 kV transmission lines in Sulaimani-Erbil network over 6 years period. The data represent the outages of the lines which consist of Scheduled and Forced outages. These data were analyzed and statistical indices calculated for the purpose of reliability evaluation.

Key words: Power system reliability, reliability indices, outage definition

INTRODUCTION

Quantitative reliability evaluation invariably leads to consideration of the data available and the data required to support such studies. Valid and useful data are expensive to collect, but it should be noted that in the long run it will be even more expensive not to collect them. It is some times argued as to which comes first: reliability data or reliability methodology. Some utility do not collect data because they have not fully determined a suitable reliability methodology. Conversely, they do not conduct reliability studies because they do not have any data. Data collection and reliability evaluation must evolve together and therefore the process is iterative. When collecting data, an unlimited amount of data can be collected. It is inefficient and undesirable to collect, analyze and store more data than is required for the purpose intended. It is therefore essential to identify how the data will be used before deciding what data to collect. Collection of data is therefore essential as it forms the input to relevant reliability models, techniques and equations. The data should therefore reflect and respond to the factors that affect reliability and enable it to be modeled and analyzed[1]. The purpose of study the reliability of this area is that: i) this region was operating more than 10 years as a split network, because of the policy of the last regime of Iraq, due to the political and economical sanction in Kurdistan region. ii) un agencies were responsible to develop the network, due to 986 UN resolution of oil for food program and UNDP was in charge with a large rehabilitation program. iii) it was necessary to identify the system maintenance requirements and to specify the weak points of the network and to list the priorities and iv) to propose and identify data collection methodology and to construct a data base file for system studies and for making analysis and planning.

DESCRIPTION OF SULAIMANI-ERBIL ELECTRICAL POWER SYSTEM

The Iraq national power system is divided for study and planning to eight electrical regions namely:

- Mosul region
- North east region
- West region
- Baghdad region
- Central Euphrates region
- Central Tigers region
- South west region
- Basrah region

The electrical power system of the three governorates in Iraq Kurdistan makes part of both Mosul region (Dohuk governorate) and northern east region (Sulaimnay, Erbil and part of Kirkuk governorate). Up to July 1994 all the above regions were operated as an interconnected system and the whole national grid was operated and controlled by the main national dispatch center and the dispatch center for north of Iraq (Mosul and Kurdistan region) as shown in Fig. 1.

Corresponding Author: Ghamgeen Izat Rashed, Department of Electrical Power Engineering,
Huazhong University of Science and Technology Wuhan, 430074, China
E-mail: gh197493@hotmail.com

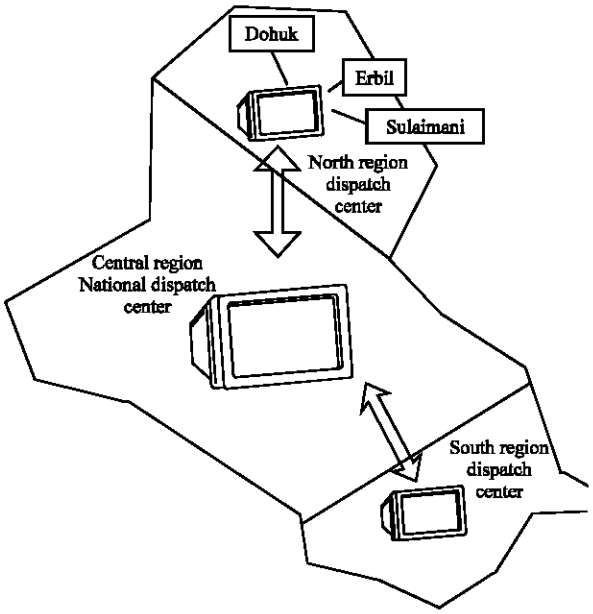

Fig. 1: Operation and control of Iraq National Grid

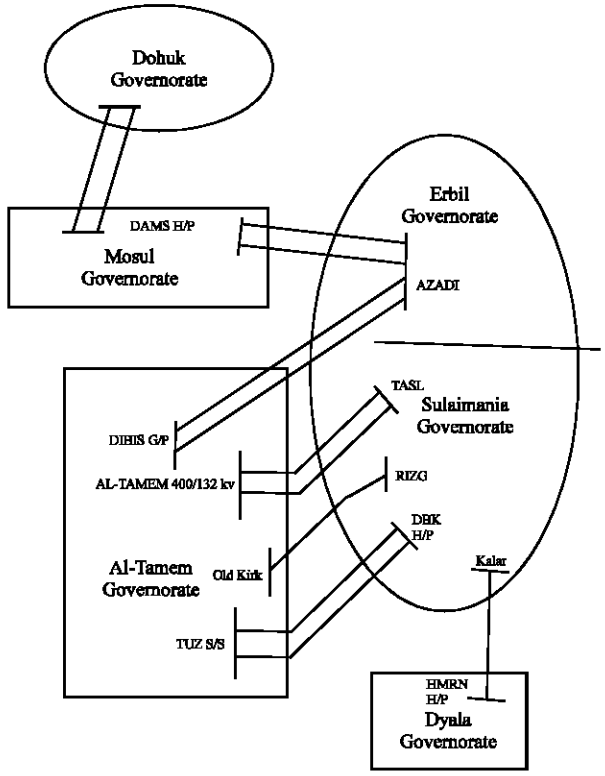

Fig. 2: Tie lines of Kudistan electrical power regions with the Iraq National Grid (Before Isolation at 1994)

Operation and planned maintenance was programmed by the planning and study departments in Baghdad[2]. Figure 2 shows Iraq-Kurdistan electrical power network before its isolation from the Iraq national grid. Prior to about 1990, there were twelve 132 kV tie lines to the region from the other Governorates of Iraq. Now there are only two 132 kV circuits which connect Dohuk Governorate to Mosul region. At present there is no any connection to Erbil and Sulaimany Governorates from the national grid. The energy supply to all three Governorates is restricted due to shortages and even the available supply is not reliable due to the present network situation. The Governorates of Erbil and Sulaimani had been cut off from the national grid and both Governorates had to rely on power from hydropower stations at Derbandikhan and Dukan, located within Sulaimani region. Only Dohuk connected with the original national grid through 132 kV line, however the electricity supply from this line was limited, infrequent and unreliable. The generation capacities of Dokan and Derbandikhan power stations however are insufficient to meet the demand. The installed capacities of these two power stations are (5x80 MW) and (3x83 MW), respectively[3].

PURPOSE OF DATA

Data can be used for one or more or both of two reasons[4]:

- Assessment of past performance
- Prediction of future performance

Data are valuable for assessing past performance of plant and systems because:

- It identifies the chronological changes in performance and therefore helps to determine weak areas needing reinforcement or plant modifications.
- It establishes existing indices which serve as a guide for acceptable value in future reliability assessments.
- It enables previous predictions to be compared with actual operating experience.

Therefore the primary advantage of accumulating reliability data is that these can be used to predict or calculate the reliability of a device when it is operated under the conditions which these data represent. It is therefore important that these data be as factual as possible in order that a high degree of confidence may be reposed in any derived conclusions. Data accuracy is particularly important when it is used for predicting reliability, because the reliability prediction technique, at best, gives us a broad estimate of the expected reliability. Therefore, it follows that more dependable data result in a higher degree of confidence in the reliability estimate[5], for this reason the quality of the data and the resulting performance indices depend on two important factors:

confidence and relevance. The quality of the data and thus the confidence that can be placed in it, is clearly dependent on the accuracy and completeness of the information complied by operating and maintenance personnel. It is therefore essential that they are made fully aware of the future use of the data and the importance it will play in later developments of the system. The quality of the statistical indices is also dependent on how the data is processed, how much pooling is done and the age of the data currently stored[6].

OUTAGE DEFINITION AND TYPE OF OUTAGES

An outage describes the state of a component when it is not available to perform its intended function due to some event directly associated with component. An outage may or may not cause an interruption of service to consumers depending on system configuration.

An interruption is the loss of service to one or more consumers or other facilities and is the result of one or more component outages, depending on system configuration[7].

A power system contains a number of generation units, transmission lines and transformers. Most of the failures of these elements can be grouped into the following four categories:

- Independent outages
- Dependent outages
- Common cause or common mode outages
- Station originated outages

DATA COLLECTION

The 132 kV transmission line field outage data for Sulaimani-Erbil region which were collected over a 6 years period consist of the following:

- Total circuit kilometers of exposure for each line
- Total number of outages of each type for each line
- List of outage durations for each type of outage for each line

The Sulaimani-Erbil 132 kV transmission system consist of 8 lines whose length vary between 25 and 99 km.

DATA ANALYSIS

The reliability data which are estimated from the collected data are:

- Forced outage rates
- Scheduled outage rate
- Forced outage duration
- Scheduled outage duration
- Outage duration

From the field outage data collected[6,8] for the transmission lines the following basic reliability indices are calculated:

$$\text{Outage Frequency} = (\text{no. of forced outages}) / (\text{total time}) \quad (\text{No.}) \tag{1}$$

$$\text{Mean Outage Time} = (\text{total outage time}) / (\text{no. of forced outages}) \quad (\text{unit time}) \tag{2}$$

$$\text{Forced Unavailability} = (\text{total outage time}) / (\text{total time}) \tag{3}$$

The results of the above reliability indices for Sulaimani and Erbil tie lines during the period (1996-2001) are shown in Table 1-8.

Forced unavailability time is the elapsed time required to make the major component serviceable again by:

- Restoring the major component to a serviceable state in its present operating position.
- Repairing the major component on site so that it becomes available for service in its present operating position.
- Repairing the major component off site so that it becomes available for service.

Table 1: Outage frequency (No./month) for Sulaimani Tie Lines during the period (1996-2001)

	Years					
Months	1996	1997	1998	1999	2000	2001
Jan.	6	11	2	5	1	12
Feb.	9	6	8	4	1	7
Mar.	8	12	9	1	7	4
Apr.	14	14	14	7	5	7
May	14	9	12	3	6	10
Jun.	7	8	4	1	2	2
Jul.	7	11	2	4	2	2
Aug.	15	1	0	12	0	2
Sep.	6	3	0	1	4	5
Oct.	3	16	0	3	1	0
Nov.	11	4	1	5	0	7
Dec.	12	3	0	2	4	5

Table 2: Outage frequency (No./month) for Erbil Tie Lines during the period (1996-2001)

	Years					
Months	1996	1997	1998	1999	2000	2001
Jan.	0	1	3	3	9	8
Feb.	2	4	12	2	3	8
Mar.	26	3	10	5	4	8
Apr.	15	3	10	9	8	4
May	0	6	12	3	6	7
Jun.	2	6	4	1	1	10
Jul.	2	1	4	3	6	1
Aug.	2	0	2	6	2	3
Sep.	4	1	0	2	3	4
Oct.	11	2	1	5	1	9
Nov.	8	7	5	2	2	3
Dec.	5	0	5	0	1	4

Table 3: Mean outage time (min.) For Sulaimani Tie Lines during the period (1996-2001)

	Years					
Months	1996	1997	1998	1999	2000	2001
Jan.	100:00:00	101:15:00	16:00:00	1102:40:00	25:00:00	1885:36:40
Feb.	592:30:00	510:00:00	151:20:00	49:30:00	20:00:00	388:36:00
Mar.	353:00:00	2273:20:00	784:42:51	9:00:00	1154:20:00	26:30:00
Apr.	571:20:00	504:51:26	1054:50:00	26:35:00	231:50:00	64:06:00
May	103:47:09	210:40:00	366:15:00	10:30:00	266:15:00	1101:30:00
Jun.	12327:20:00	26:30:00	46:00:00	15:00:00	11:00:00	105:00:00
Jul.	29:30:00	84:00:00	53:00:00	882:30:00	830:00:00	26:00:00
Aug.	129:48:00	10:00:00	0:00:00	155:56:00	0:00:00	510:00:00
Sep.	2073:20:00	47:40:00	0:00:00	10:00:00	50:30:00	162:45:00
Oct.	1227:30:00	919:22:51	0:00:00	320:00:00	1255:00:00	0:00:00
Nov.	951:56:40	674:00:00	1040:00:00	225:00:00	0:00:00	518:36:00
Dec.	661:42:51	95:00:00	0:00:00	32:30:00	361:40:00	628:00:00

Table 4: Mean outage time (min.) for Erbil Tie Lines during the period (1996-2001)

	Years					
Months	1996	1997	1998	1999	2000	2001
Jan.	0:00:00	10:00:00	32:00:00	616:30:00	194:45:00	2174:20:00
Feb.	5:30:00	448:40:00	280:15:00	202:00:00	132:30:00	236:42:51
Mar.	47:33:45	16:00:00	336:15:00	38:15:00	25:30:00	61:20:00
Apr.	359:00:00	14:30:00	11:40:00	104:06:40	310:50:00	35:40:00
May	0:00:00	15:15:00	17:40:00	70:00:00	46:45:00	208:10:00
Jun.	6:00:00	175:15:00	76:15:00	52:40:00	8:00:00	360:05:00
Jul.	3763:00:00	12:00:00	45:00:00	31:40:00	263:12:00	10:00:00
Aug.	2045:00:00	0:00:00	6:00:00	40:00:00	10:00:00	21:30:00
Sep.	370:00:00	6:00:00	0:00:00	340:00:00	8:20:00	587:30:00
Oct.	5671:50:00	6420:00:00	5:00:00	168:00:00	10:00:00	90:00:00
Nov.	984:10:00	262:05:00	115:30:00	10:00:00	40:00:00	141:30:00
Dec.	156:15:00	0:00:00	410:10:00	0:00:00	854:00:00	123:20:00

Table 5: Forced unavailability for Sulaimani Tie Lines during the period (1996-2001)

	Years					
Months	1996	1997	1998	1999	2000	2001
Jan.	0.0089606	0.0075045	0.0003584	0.038709677	0.000560036	0.048812724
Feb.	0.059387	0.0379464	0.0107639	0.002455357	0.000496032	0.046205357
Mar.	0.0201613	0.0472894	0.121371	0.000201613	0.055062724	0.001187276
Apr.	0.0969907	0.0596759	0.0859259	0.002037037	0.015902778	0.006064815
May	0.0152554	0.0260753	0.0328181	0.000403226	0.022177419	0.089448925
Jun.	0.3019444	0.001713	0.0013889	0.000347222	0.000509259	0.002430556
Jul.	0.0016129	0.0095654	0.0011873	0.0395853	0.01859319	0.001164875
Aug.	0.0269489	0.000224	0	0.01890681	0	0.011424731
Sep.	0.0962963	0.0033102	0	0.000231481	0.001805556	0.013958333
Oct.	0.0428987	0.1424059	0	0.021505376	0.028113799	0
Nov.	0.0869213	0.0171991	0.0240741	0.009837963	0	0.054282407
Dec.	0.0935036	0.0063844	0	0.001456093	0.023633513	0.033781362

Table 6: Scheduled unavailability for Sulaimani Tie Lines during the period (1996-2001)

	Years					
Months	1996	1997	1998	1999	2000	2001
Jan.	0.0170251	0.0097446	0.0077061	0.03561828	0.065053763	0.092517921
Feb.	0.0001197	0.0139385	0.0174603	0.686029506	0	0.018402778
Mar.	0.0189292	0.3549507	0.0050627	0.034296595	0.006048387	0.045295699
Apr.	0.0360417	0.376412	0.0090046	0.135300926	0.001157407	0.016759259
May	0.0203629	0.1136425	0.0104391	0.004457885	0.011648746	0.022155018
Jun.	0.0009259	0.0282176	0.0023843	0.003402778	0.043726852	0.009444444
Jul.	0.0021505	0.0051075	0.0063172	0.010573477	0.025649642	0.009767025
Aug.	0.0331541	0.005578	0.0002912	0.026680108	0	0.002016129
Sep.	0.0033102	0.0037963	0.1447917	0.001319444	0.019050926	0.010949074
Oct.	0.0133961	0.0019041	0.0152106	0.074171147	0.062724014	0.013216846
Nov.	0.0544676	0.9946221	0.0390741	0.03395833	0.415	0.030787037
Dec.	0.0590278	0.0028002	0.0373656	0.021908602	0.040210573	0.018458781

Table 7: Forced unavailability for Erbil Tie Lines during the period (1996-2001)

	Years					
Months	1996	1997	1998	1999	2000	2001
Jan.	0	0.000224	0.0010305	0.014202509	0.033333333	0.148633513
Feb.	0.0002634	0.0351687	0.0351687	0.005009921	0.003497024	0.038864087
Mar.	0.0147625	0.0005376	0.0311604	0.002755376	0.001142473	0.006272401
Apr.	0.034537	0.0006019	0.0015046	0.021689815	0.041550926	0.002013889
May	0	0.0011873	0.0023746	0.001792115	0.002620968	0.026859319
Jun.	0.0002778	0.0089815	0.0070602	0.003425926	0.00018	0.048078704
Jul.	0.0842966	0.0002688	0.0020385	0.002128136	0.027688172	0.000224014
Aug.	0.0458109	0	0.0002688	0.002688172	0.000448029	0.000649642
Sep.	0.0171296	0.0001389	0	0.015740741	0.000578704	0.027199074
Oct.	0.6964382	0.1438172	0.000112	0.01438172	0.000224014	0.015344982
Nov.	0.1074306	0.0211806	0.0096528	0.000462963	0.000925926	0.006342593
Dec.	0.0136649	0	0.0273746	0	0.019130824	0.007840502

Table 8: Scheduled unavailability for Erbil Tie Lines during the period (1996-2001)

	Years					
Months	1996	1997	1998	1999	2000	2001
Jan.	0	0.0703405	0.0138441	0.104121864	0.023521505	0.016129032
Feb.	0	0.2255208	0.0190724	0.033234127	0.015625	0.020386905
Mar.	0.1592518	0.265345	0.0497984	0.062634409	0.017585125	0.028830645
Apr.	0.0180556	0.1906944	0.0481713	0.067662037	0.004027778	0.050347222
May	0.1284946	0.2265233	0.1056676	0.09233871	0.136043907	0.064336918
Jun.	0.0007639	0.0172685	0.0033796	0.052986111	0.023009259	0.061666667
Jul.	0.0055332	0.0023073	0.0049283	0.060327061	0.02358871	0.058176523
Aug.	0.0247984	0.0409946	0	0.056966846	0.013642473	0.015815412
Sep.	0.2937269	0.0187269	0.0020833	0.263078704	0.018240741	0.063148148
Oct.	0.1046147	0.0626568	0.2334005	0.042898746	0.10707885	0.229144265
Nov.	0.0569676	0.1411343	0.0819444	0.140625	0.073217593	0.157731481
Dec.	0.083983	0	0.0457661	0.016801075	0.037768817	0.109229391

ESTIMATION OF OUTAGES RATES[8]

The outage rates of transmission line were estimated by using the scatter diagram-regression analysis method[8]. This method has a number of advantages over the method of estimating outage rates by dividing the number of outages observed during a period by the number of km-years of exposure during that period. These advantages are :

- The regression method does not assume that outages per year are directly proportional to line exposure, an assumption that appears to be very poor in some cases.
- The regression method provides a mean for making confidence statements about line outage rates.

There is reason to believe that a linear functional relationship exists between line exposure and outage per year. Hence, a linear statistical model was used to relate exposure and outage per year. The associated regression equation is :

$$Y = mX + b \tag{4}$$

Y: is the number of outages per year for a line having X kilometers of exposure. Table 9 and 10 shows forced and scheduled outage per years and line length for 132 kV transmission line in Sulaimani-Erbil region.

m and b : are the slope and intercept of the regression line. By using least square method m and b may be obtained from n data points for a particular group of lines as follows:

$$m = \frac{n\sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{n\sum_{i=1}^{n} X_i^2 - (\sum_{i=1}^{n} X_i)^2} \tag{5}$$

$$b = \frac{\sum_{i=1}^{n} Y_i - m\sum_{i=1}^{n} X_i}{n} \tag{6}$$

The value of outages per year read from a regression line for a given line exposure is an estimate of the future outage rate for such a line. The estimated variance S_E^2 is calculated by the following equations :

$$S_E^2 = \frac{1}{n-2}\left[\sum_{i=1}^{n} Y_i^2 - \left(\sum_{i=1}^{n} Y_i\right)^2 * \frac{1}{n} - m^2\left[\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2 * \frac{1}{n}\right]\right] \tag{7}$$

Table 9: Forced outage/years and line length for 132 kV transmission line in Sulaimani-Erbil region

	Line(km)	Outage/years (Y)						
List name	X	1996	1997	1998	1999	2000	2001	Total
Dokan-Tasluja 1st circuit	46	5	10	16	18	6	13	68
Dokan-Tasluja 2nd circuit	46	19	35	1	---	---	---	55
Derbandikhan-Rizgari	60	53	46	13	8	6	20	146
Derbandikhan-Kalar	70	16	17	9	8	6	24	80
Derbandikhan-Tasluja	84	54	42	23	22	21	30	192
Dokan-Erbil	98	27	14	21	10	26	26	124
Dokan-North Erbil	99	50	20	47	34	20	43	214

Table 10: Scheduled outage/years and line length for 132 kV transmission line in Sulaimani-Erbil region

	Line(km)	Outage/years (Y)						
List name	X	1996	1997	1998	1999	2000	2001	Total
Dokan-Tasluja 1st circuit	46	27	33	35	24	19	28	166
Dokan-Tasluja 2nd circuit	46	26	60	4	---	---	---	90
Derbandikhan-Rizgari	60	32	74	27	64	37	35	269
Derbandikhan-Kalar	70	42	259	47	84	52	105	589
Derbandikhan-Tasluja	84	43	57	15	39	28	27	209
Dokan-Erbil	98	61	50	48	30	35	33	257
Dokan-North Erbil	99	78	279	124	186	135	203	1005

Table 11: Regression results of 132 kV transmission line outage rates

Years	Type of outage	m outages/km year	n data points	S_E^2	$\sum X_i$	$\sum X^2$	$\sum Y$	$\sum Y^2$	$\sum XY$
1996	Forced	0.472308125	7	349.5752601	503	39193	224	9596	17536
	Scheduled	0.789195015	7	61.58823915	503	39193	309	15847	24610
1997	Forced	0.346907994	5	288.7792861	306	19788	150	5494	9548
	Scheduled	1.905304095	7	11115.2177	503	39193	812	160836	64157
1998	Forced	0.271010962	6	42.00837393	404	29392	83	1477	6182
	Scheduled	0.585686465	5	314.3784486	358	27276	141	5483	11058
1999	Forced	0.196282965	6	109.4804966	457	37077	100	2192	8062
	Scheduled	1.291779916	6	3642.710424	457	37077	427	48745	35454
2000	Forced	0.289638231	3	15.44640464	229	18973	47	877	4020
	Scheduled	1.134503783	6	1535.446816	457	37077	306	24668	25881
2001	Forced	0.405935503	6	35.03335047	457	37077	156	4570	12803
	Scheduled	1.546683317	6	4918.315948	457	37077	431	56061	36337
1996-2001	Forced	1.84793947	6	2366.384779	457	37077	824	130376	66954
	Scheduled	4.818546589	4	196378.1436	351	31361	2060	1466676	183467

The results of outages/km. Year obtained by this method for both forced and scheduled outages was shown in Table 11.

ESTIMATION OF OUTAGES DURATION[8]

The mean outage duration (r) for each type of outage are calculated by using:

$$r = \sum_{i=1}^{n} \frac{t_i}{n} \tag{8}$$

Where, t_i: is the length of the ith outage duration and n is the number of outage durations. The estimated variance of (r) may be evaluated as follows:

$$S^2 = \frac{\sum_{i=1}^{n} t_i^2 - \frac{(\sum_{i=1}^{n} t_i)^2}{n}}{n-1} \tag{9}$$

The result for this calculation shown in Table 12. Another method used for finding total forced and scheduled outages/km year for all 132 kV transmission lines in Sulaimani-Erbil region by:

$$\text{Total outages/km year} = \frac{\text{Total outages for all lines/year}}{\text{Total line length in km}} \tag{10}$$

The result for this calculation is shown in Table 13, the result obtained by tshis methods approximately equal to the result obtained by the linear regression methods.

CONCLUSIONS

Collection of data: The outages data are obtained from checking out all the available reports individually at Dokan and Derbandikhan hydropower station control centers in Sulaimani-Erbil network and from these files the

Table 12: 132 kV transmission line outage duration results

Years	Type of outage	r minutes	n data points	S^2	$\sum t_i$	$\sum t_i^2 * 10^6$
1996	Forced	15880.28571	7	66647670.24	111162	2165.170342
	Scheduled	10242.14286	7	71615497.81	71695	1164.003419
1997	Forced	5617.857143	7	40490061.81	39325	463.862603
	Scheduled	35678.85714	7	2899121329	249752	26305.593904
1998	Forced	2696.571429	7	4250379.952	18876	76.402762
	Scheduled	6402.285714	7	36832851.24	44816	507.921944
1999	Forced	1662.833333	6	3240332.567	9977	32.791751
	Scheduled	17416.16667	6	89719136.97	104497	2268.532853
2000	Forced	2430.5	6	2394315.9	14583	47.415561
	Scheduled	8882.333333	6	60663344.27	53294	776.691794
2001	Forced	6202.833333	6	15753585.37	37217	309.618775
	Scheduled	10466.83333	6	154831834.6	62801	1431.486773
1996-2001	Forced	34064	6	213118398.4	204384	8027.728568
	Scheduled	96283.66667	6	5296217608	577702	82104.354842

Table 13: Total outages/km year uuring (1996-2001) for all 132 kV transmission lines in Sulaimani-Erbil region obtained from method two

Year	Type of outages	Total line km	Total outages for all lines/year	Total outages/km year
1996	Forced	503	224	0.445328032
	Scheduled	503	309	0.614314115
1997	Forced	503	184	0.365805169
	Scheduled	503	812	1.614314115
1998	Forced	503	130	0.258449304
	Scheduled	503	300	0.596421471
1999	Forced	457	100	0.218818381
	Scheduled	457	427	0.934354486
2000	Forced	457	85	0.185995624
	Scheduled	457	306	0.669584245
2001	Forced	457	156	0.341356674
	Scheduled	457	431	0.943107221
1996-2001	Forced	457	824	1.803063457
	Scheduled	457	2459	5.380743982

outages for each line for every day are registered in a special form and it is reported for months and after that for years. One of the difficulties faced in process of data collection was that unregular and disturbent manner of the registration of the data and recording it.

Frequency and duration of outages: Frequency of outages and durations are found to have high values especially during the years 1996 and 1997. This however, is due to:

- Problems in the existing 132 kV transmission line
- Weather status
- Unavailability of suitable equipment and components for repairing and maintenance. From the collected data, it can be seen that the 132 kV transmission lines occasionally switched off due to the whole system shutting down, even there were not planning outages in the line.

Unavailability: Due to maintaining and rehabilitation of the lines, average of forced unavailability for north Iraq transmission line decreased in the year 2001 while average of scheduled unavailability was increasing in the same year. The forced outages that appeared in the line most likely due to line short circuits which lead to enable operating the protection systems automatically and stand the line out of service.

Outages/km year: The results for both methods used for determining outages/km year are approximately the same and from the regression methods we conclude that the estimated number of outages increase with increasing the line length.

Seasonal effect on frequency and durations: a)Frequency of outages are of a high values relatively at winter and spring season and these high values are due to the effect of bad weather on these outages. b)Average of mean outage time in autumn, winter and spring season are of a high values due to the effect of weather on delaying repairing programs of the lines. This mean that the climatic conditions has a significant effects on the line outages.

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