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Performance Evaluation of 132kV grid Stations and Transmission lines in Peshawar Division. A Case Study

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Abstract

This paper presents a comparative performance evaluation of all 132 kV grid stations and 132kV short transmission lines in Peshawar division. The performance of grids and transmission lines were estimated by statistical data analysis for summer season with peak loads. Line losses, efficiency, transformers loading index (TLI) and transmission line loading index (LLI) parameters were considered for the evaluation of poor and high performance 132kV grid stations and transmission lines connecting these grids in a large inter connected system. The power transformers and transmission lines with more than 50% TLI and LLI values were declared over loaded according to N-1 international standard security system for power system. Graphical presentations for clear comparison was provided, hence the over loaded lines should be reassured and transformers should be up graded with their loading capacities, wherever it is required. The results and analysis will be helpful for local power utilities in power system enhancementsforecasting and up gradations in near future.

Keywords: Transformer loading index, Transmission line loading index, 132kV grid stations, Line losses, Efficiency of transmission lines.

1. Introduction

Electric energy can be transported easily at reasonable cost and efficiency by high voltage transmission lines (J. Duncan*et al.*, 2008). Transmission lines connect distribution grids with centralized power generating stations as well as other grids to make the power system reliable and to enhance power carrying capability. Modern power systems are inter connected all over the world. The major part of our Pakistan Electric power system is also large inter connected. The interconnected power system have advantages of high reliability, more power transfer capabilities and compensate system over loading during peak hours in summer seasons. Power system is categorized as generating stations, transmission system, distribution system and load centers or consumers.

The Transmission and Distribution (T&D) system is electrically characterized by Line Parameters like Resistance, Inductance, Capacitance and Conductance. These parameters are uniformly distributed over the length of T&D system (K.Mehta and R. Mehta, 2002)**.** When load is connected with the distribution system then losses took place due to the resistance of feeders and all connecting conductors. While major losses are considered that of power and distribution transformers Copper and iron Losses known as Technical losses**(**Yasen and Mustafa, 2010**).** There are basically two types of losses i.e. Technical and Non-technical losses (Adeoye, Ekejiuba C.O, 2014). Water and Power Development Authority (WAPDA) and National Transmission and Despatch Company (NTDC) published report **(**G. S. Kalol*et al*. 2014**)** for 2011-2012 period, declaring that 26 - 30% losses took place in T&D system with voltage variation up to 10% rated value. Non- Technical Losses are due to aging of Equipments of power system, Human errors in measurements of kWh on Energy meters and the theft of electricity also comes under non-technical losses. These losses results in the reduction of efficiency of overall system **(**M. C. Anumaka, 2012**).**Generally, system losses increase the operating cost of electric utilities and consequently result in high cost of electricity.

Several related works have been performed in different countries and in Pakistan. In Bahawalpur technical Distribution feeders were evaluated by (G. S. Kalol*et al*. 2014**)** for the different periods and in the last these losses were compared. The feeders with high losses and less were mentioned. It was also discussed that as compared to 2011, these technical and non-technical losses increased or not. Same case study was performed in Nigeria in grids and technical and non-technical losses were estimated for the investigation of distribution system **(**Omar H. Abdalla, 2010**)** in Oman Grid system worked for the performance evaluation considering transmission line loading and LLI and Transformers loading index and % loading without Distributed Generation integration (DG) to these grids and with DG installation. The performance in 2010 for Oman grid system was compared. Showing improvement in efficiency, losses, transformers loading and transmission line loading reductions with DG.

The efficiency and lifetime of the power system equipment depends upon mostly on the loading on these equipments. The loading of the each equipment in the power system vary from time to time. In summer, Power and Distribution Transformers and Transmission lines are seriously loaded and operate with full capacity. Two important indices transformer loading indices (TLI) and Line Loading Index (LLI) are defined and are used to calculate the values for Transformer loading and Transmission Line loading. Transformer loading index is the percentage average transformer loading in a grid or substation. It may be the percentage average Transformer Loading in national grid. Line loading Index is the percentage average transmission line loading. These indices are of the utmost important in power system. These indices are also called Performance Indicator of the Power system. According to the (N-1) security system(Omar H. Abdalla, 2010), loading of transformer and Transmission Line should never be overloaded above 50% as it will make the system less efficient.

Line losses on the transmission lines, is one of the major problems affecting power generation and distribution. The contrary effect of these on the budget cannot be over emphasized as it cuts across every sphere of life ranging from comfort to investment. This paper therefore is meant to outline these losses, the cause and to puffer solution to the problems with Peshawar Division as a case study. In this paper the Line losses, efficiency, Transmission line loading index and transformer loading index in Peshawar division for 132kV grid stations are discussed. The performance evaluation is necessary to investigate which transformer andtransmission line is performing well and which one is to be upgraded in future to make the power system efficient. Also the loading of transformer and 132kV Transmission lines were compared for the month of April, 2014, summer season. These performance evaluating parameters i.e. TLI and LLI are calculated and compared with the (N-1) security system. This work will help in correct up gradation and power system improvement projects.Graphical analyses are taken place and found out the worst and best cases in the power system. MATLab and MS Excel are used for statistical analysis.

2. Solution Methodology:

2.1 Technical Losses and Efficiency of Transmission Lines

Some losses occur due to line resistance and may be considered. These are calculated in kilo Watts or Mega Watts and are added to the power demand in MW on grid station. So we have find out the line resistance and then calculated line losses (Muhammad Iftikhar *et al*., 2014).The mathematical expression to find out the per phase losses due to resistance of the line is as below. As the losses in the grid station and in Transmission lines are calculated by using the following relation:

$$\text{Line Losses} = I^2 Rac \qquad (1)$$

Where I is the maximum current in Amperes:

Rac is the AC resistance of the Transmission Line:

Technical losses in power system also includes energy losses in Mega Watt Hour (MWh), which is the numerical difference between the energy generated in generating stations and energy received at distribution grid or other connected grid.

$$\text{MWh energy losses} = \text{MWh generated} - \text{MWh received} \qquad (2)$$

Technical and non-technical losses are helpful in evaluating how much the power system is efficient. For short transmission line having length less than 80km, the efficiency (K.Mehta and R. Mehta, 2002) of the line is calculated as under;

$$\% \ Transmission \ Line \ Efficiency = \frac{Vr \ Ir \ Cos\phi r}{Vr \ Ir \ Cos\phi r + total \ \ losses} \times 100 \quad (3)$$

2.2 Power Transformers Loading Index (TLI)

The percentage overloading of a Transformer is given by:

$$\% \ \text{Transformer Loading} = \frac{\text{Actual Secondary current}}{\text{Rated capacity of the secondary current}} \times 100 \qquad (4)$$

Eq. (4) shows how much load is connected with secondary of a transformer. According to (N-1) security system, the performance parameter for Transformer is Transformer Loading Indices (Omar H. Abdalla, 2010) is given as:

$$\text{TLI} = \frac{\sum_{n} (\text{All transformer loading for a grid})}{n} \qquad (5)$$

Where n is the number of transformer in a grid.

TLI evaluated for the total number of power transformers of different MVA ratings (n=38 transformers) in 132kV grid stations is calculated as under:

$$\text{TLI} = \frac{\sum_{i=1}^{n=38} (\% \ \text{Loading of each Transformer})}{n} \quad (6)$$

2.3 Transmission Lines Loading Index (LLI)

Now the percentage loading of transmission line is given below as:

$$\% \ \text{Transmission Line Loading} = \frac{\text{Actual load on Transmission Line}}{\text{Rated capacity of the Transmission Line}} \times 100 \qquad (7)$$

The performance parameter for Transmission line is Line Loading Indices (LLI) and given as:

$$LLI = \frac{\sum_{L}(\text{All transmission Line loading })}{L} \quad (8)$$

Where L is the number of Transmission Line.The data was obtained from Peshawar Electric Supply Company (PESCO) grid Stations for the month of April, 2014. After statistical data analysis the losses, Efficiency and Loadings of each Transformer in each grid and 132kV transmission line was calculated. Table 1 is illustrating Transformer loading and TLI calculated, while in Table 2 Losses, Efficiencies, Loading and LLI of 132kV Transmission Line are presented. Line loading index declares about the performance of line in a better way due to the fact that if line is overloaded, consequently a high current will flow across the line with poor power factor and high line losses and voltage drops may occur.

TABLE 1 TRANSFORMER LOADING AND TLI.

132kV Grid Station	*Power Transformers in grids*	*Rating of Power Transformers MVA*	*Transformers % Loading in grids*	*TLI*
Dalazak	2	20/26	72.8	72.42
		20/26	72.03	
Hayatabad	3	31.5/40	85.16	61.93
		31.5/40	1	
		20/26	99.62	
Jamrud	4	31.5/40	54.03	88.13
		20/26	100	
		20/26	101.15	
		20/26	97.32	
Mattani	3	10/13	99.54	100.61
		20/26	101.15	
		20/26	101.15	
Peshawar Industrial	3	31.5/40	94.62	98.71
		20/26	101.92	
		31.5/40	99.6	
Peshawar Cantt	4	20/26	86.59	85.44
		20/26	98.08	
		20/26	84.29	
		20/26	72.8	
Peshawar City	3	31.5/40	66.73	69.55
		31.5/40	74.7	
		31.5/40	67.23	
Peshawar Fort	2	31.5/40	91.14	70.87
		31.5/40	50.6	
Peshawar University	3	31.5/40	98.41	82.52
		31.5/40	95.62	
		31.5/40	53.54	
	3	10/13	104.13	69.93

Rahman Baba		31.5/40	32.87	
		20/26	72.8	
Sakhia/ma	2	20/26	52.87	76.63
		20/26	100.38	
Shahibagh old	4	20/26	91.95	75.54
		31.5/40	58.76	
		31.5/40	91.69	
		31.5/40	59.76	
Warasak	2	10/13	98.32	99.35
		20/26	100.38	

TABLE 2 LOSSES, EFFICIENCIES, LOADING AND LLI OF 132KV TRANSMISSION LINE.

Name of Transmission Line	***Technical Line losses ($3I^2R$) MW***	***Power demand(MW)***	***Transmission lines %Efficiency***	***%Loading***
WSK-SBGH1	809	75	98.93	75.3
WSK-SBGH2	712	60	98.83	61.48
WSK-Pcantt	178	90	99.80	92.21
WSK-JMR	1396	84	98.37	86.07
S/M-MTN	248	50	99.51	51.23
S/M – PCY	248	57	99.57	32.83
S/M-PIND	1398	56	99.75	56.22
S/M-RHB	207	57	99.64	32.83
S/M-PUN	1278	84	99.85	84.34
JMR-PUN	177	32	99.45	32.79
PUN-PCANTT	4792	36	98.69	36.89
SBGH-PFT1	26.60	28	99.91	16.13
SBGH-PFT2	16.70	22	99.92	12.67
SBGH-DLZK	1042.5	100	98.97	102.46

PUN-PIND	219	24	99.10	24.59
PUN-S/M	905	66	98.65	66.27
PIND-S/M	1307	70.4	98.18	70.68
JMR-HYTAB	94.50	44	99.79	45.08

It is illustrated in table 2 that double circuit 132kV transmission to Shahi Bagh Grid Station is less than 20% loaded and hence there are total of 43.30kW losses. The line connecting Sheikh Muhammadi Grid Station to Rahman Baba Grid is only 32.87% loaded and it is shown that the line has high efficiency and less Losses in kW. The most efficient line with efficiency 99.79% is from Jamrud to HayatAbad grid Station, which is 2.71 km long and line is loaded less than 50%.

3. Results and Calculation:

Statistical data analysis for all the 132kV transmission lines and 132kV Grid Stations in Peshawar Division have been performed. Transmission lines performance for their losses, efficiencies and loading conditions with loading index is presented. The below graph clearly illustrated that some transmission lines have negligible losses while some transmission lines have few megawatts losses which shows the poor performance of these transmission lines.

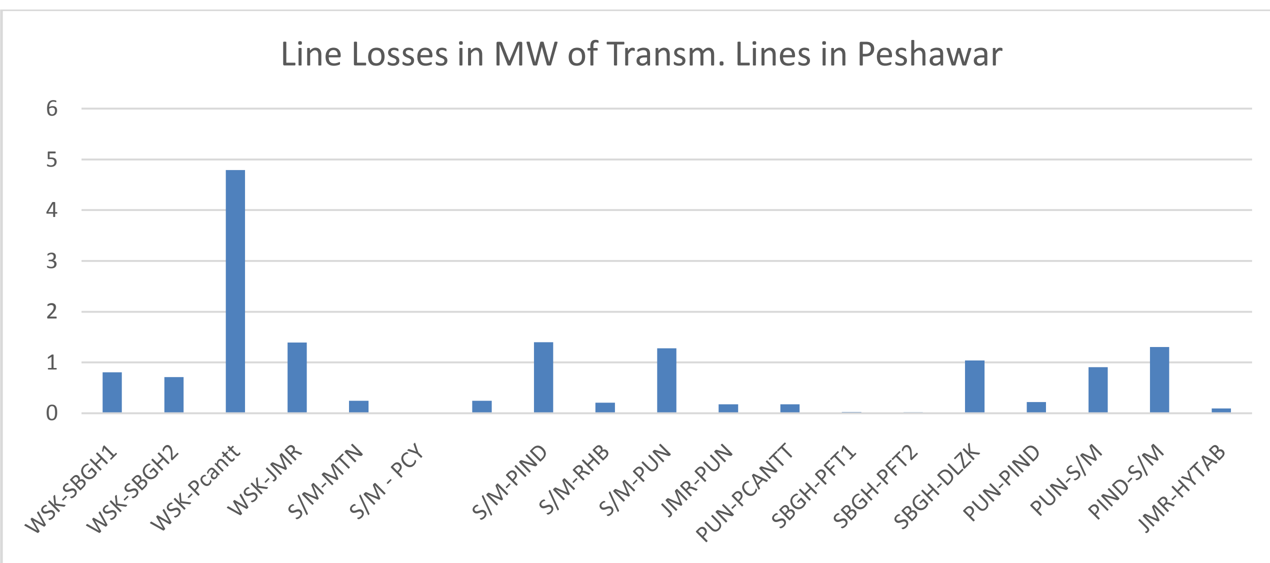

Figure 1: Transmission Lines losses in MW of Peshawar division

The Transmission lines with 3 highest efficiencies of all the Peshawar transmission lines, Power demands and maximum current recorded for the month of April are presented in table 3. Transmission lines with poor performance comparatively are presented in table 4. Three lines connecting Jamrud grid withWarsak Power House, Peshawar industrial grid with Sheikh Muhammadi grid station and Peshawar university grid with Sheikh Muhammadi Grid have high losses and high loading index.

TABLE 3. TRANSMISSION LINES WITH HIGH PERFORMANCE

Name of T/Lines	***Load Current I(A)***	***Total Line Losses (MW)***	***Power Delivered (MW)***	***% Efficiency***
SBGH-PFT2	110	0.0167	22	99.92
SBGH-PFT1	140	0.0266	28	99.91
S/M-P_{UN}	420	0.1278	84	99.85

TABLE 4. TRANSMISSION LINES WITH POOR PERFORMANCE

Name of T/Lines	***Load Current I(A)***	***Total Line Losses (MW)***	***Power Delivered (MW)***	***% Efficiency***
WSK-JMR	420	1.396	84	98.37
P_{UN}-S/M	330	0.905	66	98.65
P_{IND}-S/M	352	1.307	70.4	98.18

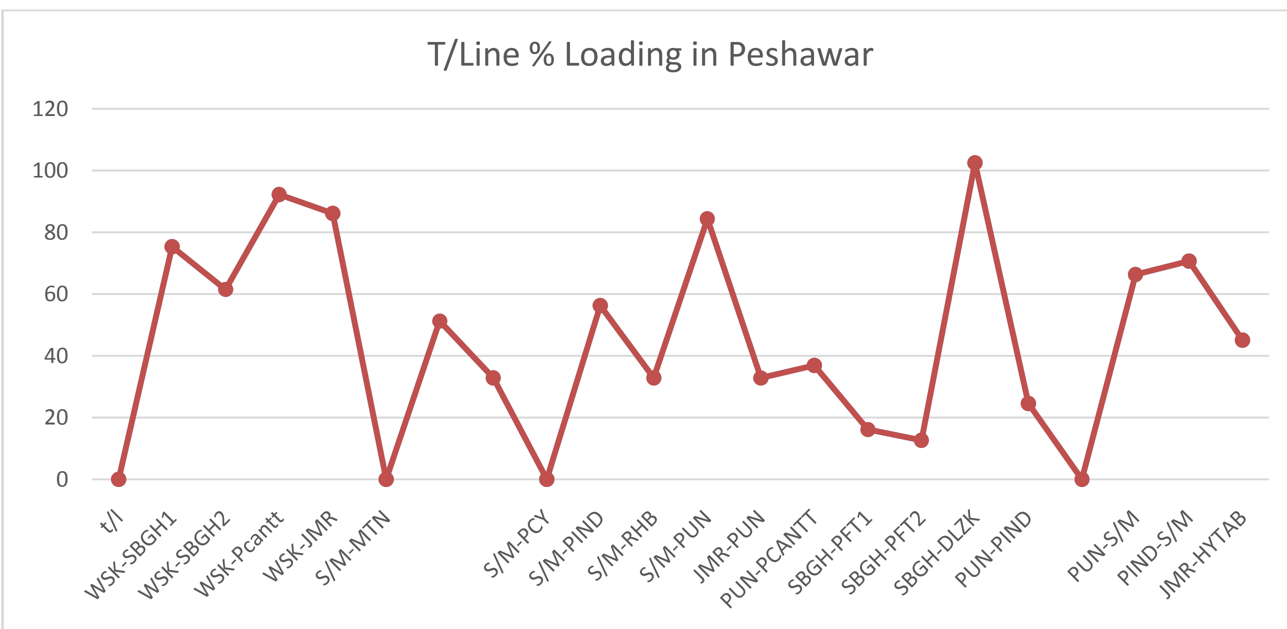

Figure 2: 132kV Transmission Lines Comparison for its % Loading

Power Transformers loading index in grid stations are evaluated in order to investigate the performances of transformers thoroughly. Below bar graph presents that all power transformers in whole Peshawar division have higher loading index than (N-1) security standards, which states that if the transformer is providing amperes to load more than half its capacity, it will be considered as overloaded. Hence all transformers are overloaded in Peshawar and the performance of these transformers will be obviously poor, failing in fulfillment load power demand. Six transformers have more than 80% loading index and three Grid Stations have this index of greater than 95%. These must be upgraded for the load requirements and better power system performance.

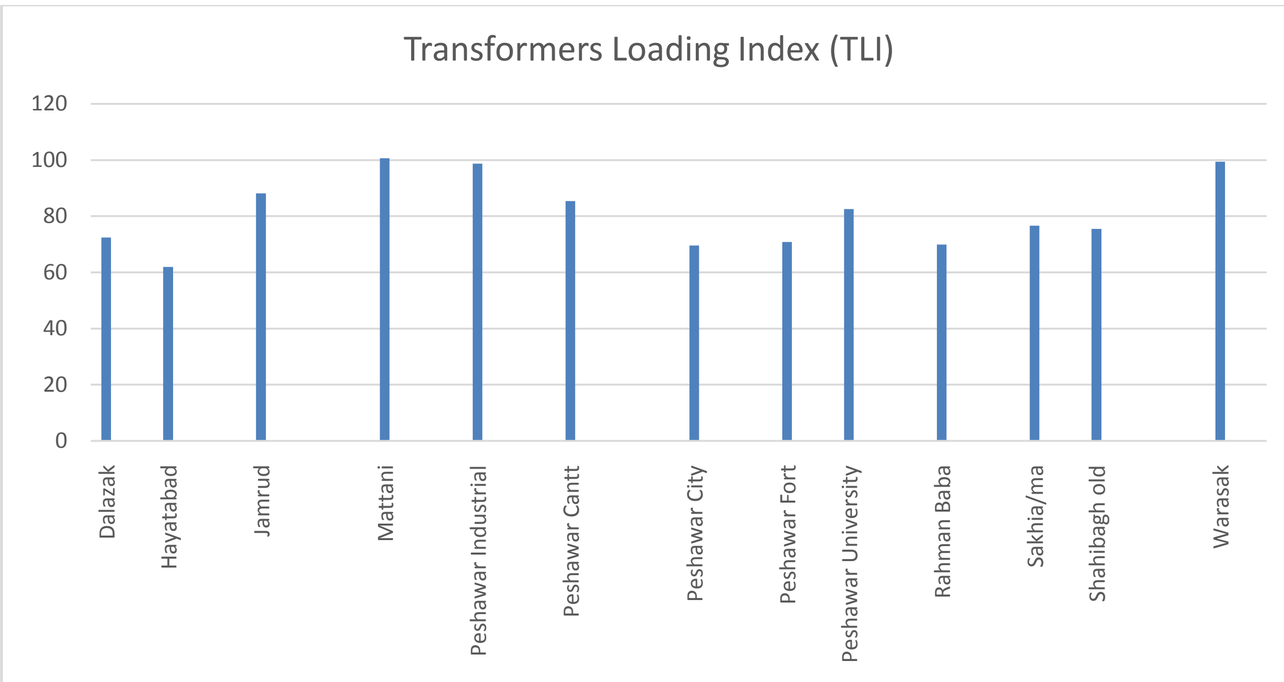

Figure 3: Power transformers Loading Index (TLI)

The graph shown below is the comparison for 132kV power grids in all over the Peshawar division on the basis of their power demands in MW on each. The Warsak power house during the month of April, 2014 was generating 142.24 MW and was capable to feed only load of such demand. Sheikh Muhammadi grid station is the largest grid in Peshawar that comes under NTDC as it is of 5oo kV level but its 132kV switch yard is providing 113.92 MW. Rahman Baba grid station is the only grid which is not capable in particular month to feed more than 20 MW, as it is delivering just 18.34.

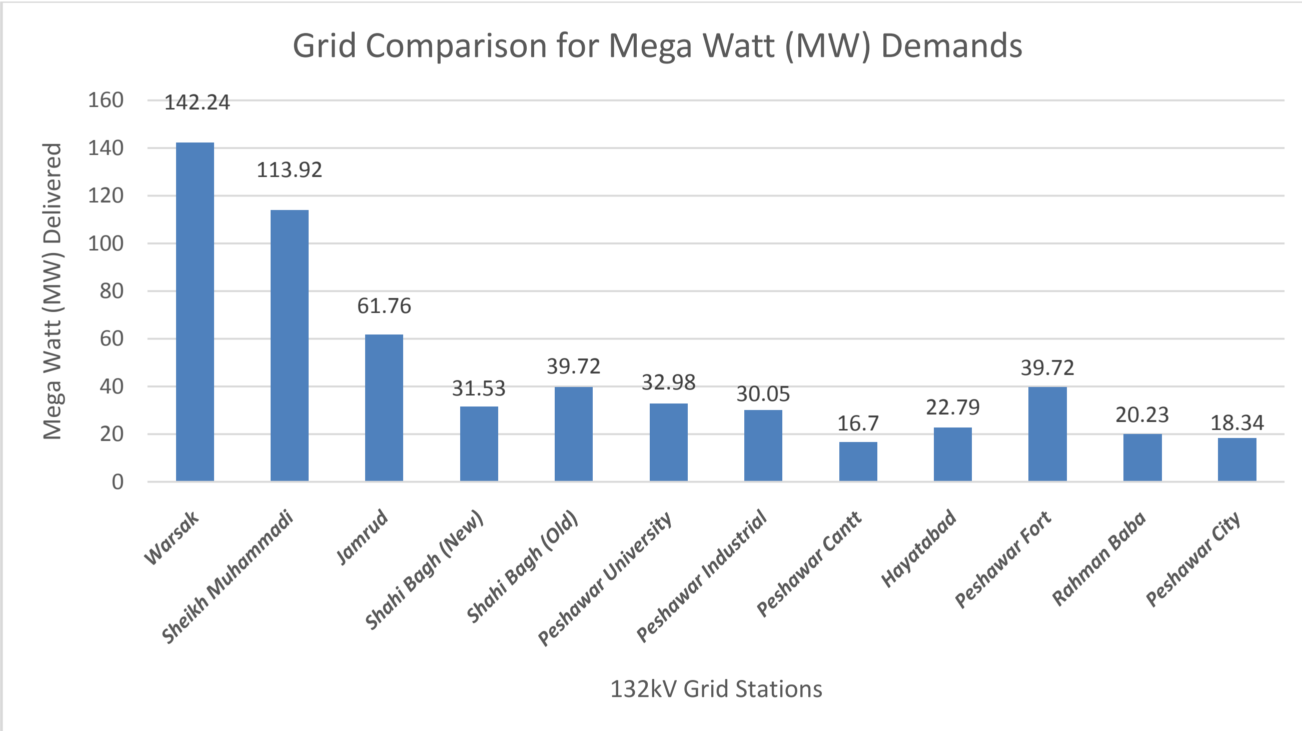

Figure 4: Power demands in April on transmission lines

4. Conclusion

To make the electric power system of Peshawar division an efficient and economical, comparative performance analysis of 132kV Grid stations, Power transformers and High Voltage transmission lines was evaluated in summer season. After the statistical data analysis it is obtained that most of the power transformers are overloaded whole month and complete year. This is why major line losses occurred in transformers as well as in High voltage Transmission lines. Transmission lines performance was evaluated on the basis of three basic performance parameters, Efficiency, Transformers loading index and transmission line loading index. Transmission lines with high losses, poor efficiency and high loading index were presented for improvement and up gradation purpose, to make them reliable, efficient and more economical. It is also evaluated that most of grid stations are not operating efficiently because the power demands on grids are more while grids are unable to fulfill demands during peak hours of the day. Comparison was performed for the power transformers also and best and worst operating transformers were estimated with their % loading indices. In future a lot of work can be done in this area by implementation of different methods and techniques to improve the existing power system of Peshawar efficiency and reliability during peak demand especially in hot summer season.

References

Adegboyega Gabriel A, Onime Franklin (2014), “Determination of Electric Power Losses in Distribution Systems: Ekpoma, Edo State, Nigeria as a Case Study”, *the International Journal of Engineering and Science (IJES)*, Volume: 3 Issue, 01, Pages: 66-72,

Adeoye, O .S, and Ekejiuba C.O (2014), “Assessment of line losses and methods of reduction on selected Power transmission lines in Nigeria”. *International Journal of Novel Research in Engineering and Applied Sciences (IJNREAS)* 1(3).

Anis Ur Rehman, Muhammad Iftikhar Khan, Khadim Ullah Jan (2014), “Comparative Analysis of 132kV Grid Stations from Distributed Generation Perspective”, *International Journal of Science and Engineering Research (IJSER)*, Volume 5, Issue9,(ISSN 2229-5518).

G. S. Kalol, M. H. Baloch, M. K. Maheshwari, R. B. Lashari (2014), “Analysis and Estimation of Technical Losses in Urban Distribution Feeders Bahawalpur”, *Sindh Univ. Res. Jour. (Sci. Ser.)* Vol. 46 (1) 33-36

J. Duncan Glover, Mulukutla S. Sarma, Thomas J. Overbye (2008),“Power System Analysis and Design” 4th Edition.

M. C. Anumaka (2012), “analysis of technical losses in electrical power system (Nigerian 330kv network as a case study)”, IJRRAS 12 (2), August.

Mohammed Hammed Yasen, Sameer S. Mustafa, “Evaluation of Electric Energy Losses in Kirkuk Distribution Electric System Area”, 1st international conference on energy, power and control in Basrah, Iraq, December, 2010.

Omar H. Abdalla, Hilal S. AI-Hadi, and Hisham A. AI-Riyami (2010), “Performance of Oman Transmission System with Distributed Generation”, *IEEE International conference of power transaction in Oman.*

V.K. Mehta and Rohit Mehta (2002) “Principles of Power System”, 4th Edition, India.