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WIND ENERGY PENETRATION INTO GRID TO MITIGATE THE UI IMPACT ON UTILITIES

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ABSTRACT
This paper view and propose a suitable scenario by which the UI implication on utility can be diminishes by wind energy penetration into the grid. As after implementation of frequency based tariff or Availability Based Tariff (ABT) state utilities are penalise for overdrawal from the grids at lower frequency. If the wind generation is available at less tariff rate as comparison to over drawal UI rate for state utilities than this will possibly mitigate the impact. Here the case study has been done in context to the state of Rajasthan, which is having ample wind energy potential. This proposed scenario shall be helpful in mitigate the UI impact on Utilities

Keywords
Availability Based Tariff (ABT), Over- Drawal, Renewable Energy Source, Under-Drawal, Utility, Unscheduled Interchange (UI), Wind Turbine Generators (WTG),

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I. Introduction

In the present scenario, Indian power sector is under the phase of de-regulation. After implementation of de-regulation in power –sector, the state distribution utilities are mostly affected. The additional UI rates for overdrawal from grid are much higher for State Utilities. Earlier major step in the power sector was the implementation of Availability Based Tariff (ABT)[1].It was introduced in India on 1st July 2002 in Western region and its main aims were (a) to maintain grid discipline (b) promote trade in energy and capacity (c) encourage higher generation availability (d) economic load dispatch. This tariff is three part tariff and it consists of (a)Fixed Charges (b)Variable Charges and (c)UI (Unscheduled Interchange's).But this commercial mechanism became the hazardous to the entire grid security.It can also be seen from recent blackouts in Northern Region Grid on 30 July 2012 and 31 July2012.UI mechanism encourages state utilities to overdrawal at higher grid frequency and discourage during lower grid frequency some time without incorporating system constraints.

As the overdrawal rates[2],[3] are high after particular frequency band as shown in Table.1.1 . Due to higher overdrawal UI rates and scarcity of power generation in states, leads to financial implication on Utilities, here the case had been studied while comparing the UI rates and corresponding wind turbine generator tariff.

India is varying geographical terrain and energy resources are wide spread. It is due to geographical condition fossils fuels are mainly concentrated at particular territory region . Usually these energy resources are used by particular territory region mostly .If these energy resources are used by other part of world than, it will definitely increase energy generation cost. Here suitable scenario has been proposed by harnessing the energy resource which is available at fuel zero cost. As Indian power system is operated as five Regional grids viz., Northern Regional grid (NR), Western Regional grid (WR), Eastern Regional grid (ER), Southern Regional grid (SR) and North Eastern Regional grid (NER). The Northern Regional grid consists of the states (1) Rajasthan (2) Uttar Pradesh (3) Jammu & Kashmir (4) Delhi (5) Uttar Pradesh (6) Punjab (7) Haryana (8) Himachal Pradesh (9) Uttranchal.

Table: 1.1 Showing the UI rate Table.

Frequency (Hz) Vs UI Rate w.e.f. 03.05.2010

Frequency		UI Rate (Rs./kWh)	UI Rate (Rs./kWh)(In case of O/D)	Frequency		UI Rate (Rs./kWh)	UI Rate (Rs./kWh)(In case of O/D)	Frequency		UI Rate (Rs./kWh)	UI Rate (Rs./kWh)(In case of O/D)
Code	Hz			Code	Hz			Code	Hz		
0	49.00	8.730	17.460								
1	49.02	8.730	17.460	26	49.52	7.790	7.790	51	50.02	1.395	1.395
2	49.04	8.730	17.460	27	49.54	7.320	7.320	52	50.04	1.240	1.240
3	49.06	8.730	17.460	28	49.56	6.850	6.850	53	50.06	1.085	1.085
4	49.08	8.730	17.460	29	49.58	6.380	6.380	54	50.08	0.930	0.930
5	49.10	8.730	17.460	30	49.60	5.910	5.910	55	50.10	0.775	0.775
6	49.12	8.730	17.460	31	49.62	5.440	5.440	56	50.12	0.620	0.620
7	49.14	8.730	17.460	32	49.64	4.970	4.970	57	50.14	0.465	0.465
8	49.16	8.730	17.460	33	49.66	4.500	4.500	58	50.16	0.310	0.310
9	49.18	8.730	17.460	34	49.68	4.030	4.030	59	50.18	0.155	0.155
10	49.20	8.730	12.222	35	49.70	3.870	3.870	60	50.20		
11	49.22	8.730	12.222	36	49.72	3.720	3.720	61	50.22		
12	49.24	8.730	12.222	37	49.74	3.565	3.565	62	50.24		
13	49.26	8.730	12.222	38	49.76	3.410	3.410	63	50.26		
14	49.28	8.730	12.222	39	49.78	3.255	3.255	64	50.28		
15	49.30	8.730	12.222	40	49.80	3.100	3.100	65	50.30		
16	49.32	8.730	12.222	41	49.82	2.945	2.945	66	50.32		
17	49.34	8.730	12.222	42	49.84	2.790	2.790	67	50.34	ZERO	ZERO
18	49.36	8.730	12.222	43	49.86	2.635	2.635	68	50.36		
19	49.38	8.730	12.222	44	49.88	2.480	2.480	69	50.38		
20	49.40	8.730	12.222	45	49.90	2.325	2.325	70	50.40		
21	49.42	8.730	12.222	46	49.92	2.170	2.170	71	50.42		
22	49.44	8.730	12.222	47	49.94	2.015	2.015	72	50.44		
23	49.46	8.730	12.222	48	49.96	1.860	1.860	73	50.46		
24	49.48	8.730	12.222	49	49.98	1.705	1.705	74	50.48		
25	49.50	8.260	8.260	50	50.00	1.550	1.550	75	50.50		

O/D During any time block is restricted to 12 % of Schedule Drawal or 150 MW whichever is lower when frequency is below 49.7 Hz and 3 % of a Daily Aggregate Basis for all the time blocks when the frequency is below 49.7 Hz.

Table:1.2 Showing the Estimated Gross Wind potential and Total Wind Capacity in States of India.

State	Estimated Gross wind potential* (MW)	Total Capacity (MW) till 31.03.2012
Andhra Pradesh	8,275	245.5
Gujarat	9,675	2,966.30
Karnataka	6,620	1,933.50
Kerala	875	35.1
Madhya Pradesh	5,500	376.4
Maharashtra	3,650	2,733.30
Orissa	1,700	-
Rajasthan	5,400	2,070.70
Tamil Nadu	3,050	6,987.60
Others	450	3.2
Total (All India)	**45,195**	**17,351.50**

Note :*Gross potential is based on assuming 1% of land availability for wind power generation in potential areas.

In the Northern Region only state of Rajasthan is having ample amount of wind potential as compared to other states in its region as from Table.1.2.[4],[5].The Northern region grid also having less total installed capacity as comparison that of western region and less renewable source of energy compared that of Western and Southern region as seen from the Table-1.3.[6].

Table-1.3 All India region wise generating installed capacity (mw) of power utilities including allocated shares in joint and central sector utilities (as on 31-12-2012)

SL. NO.	REGION		THERMAL			Nuclear	HYDRO	R.E.S.@	TOTAL
		COAL	GAS	DSL	TOTAL		(Renewable)	(MNRE)	
1	Northern	31323.5	4671.26	12.99	36007.75	1620	15456.75	4623.24	57707.74
2	Western	43099.5	8254.81	17.48	51371.79	1840	7447.5	8450.04	69109.33
3	Southern	23782.5	4962.78	939.32	29684.6	1320	11353.03	12096.78	54454.41
4	Eastern	22607.88	190	17.2	22815.08	0	3882.12	436.71	27133.91
5	N. Eastern	60	824.2	142.74	1026.94	0	1200	243.28	2470.22
6	Islands	0	0	70.02	70.02	0	0	6.1	76.12
7	All India	120873.38	18903.05	1199.75	140976.18	4780	39339.4	25856.14	210951.72

Captive Generation Capacity in Industries having demand of 1 MW or above, Grid interactive(as on 31-03-2011)=34444.12 MW

At present the state of Rajasthan is having a wind installed capacity more than 2100 MW. This installed capacity includes the Agreements related to:-

1.1 Power Purchase Agreement.
1.2 Power Purchase cum Wheeling and Banking Agreement.
1.3 Wheeling and Banking Agreement.
1.4 Renewable Energy Certificate Mechanism.

1.1 Power Purchase Agreement: These agreements are done to purchase wind energy through tariff decided by the regulatory commission on preferential tariff and duration of PPA was generally of 20 years to 30 years. In this power injected by the wind turbine generator is directly to Utility and tariff[7] for wind turbine generator in state of Rajasthan as follows:-

(1) Fy-(10-11) -Rs 4.10 per Kwh
(2) Fy-(11-12) -Rs 4.46 per Kwh

1.2 Power Purchase cum Wheeling and Banking Agreement: These agreements consists of certain ratio in which the some part of injected power is sale to utility and rest of energy injected is used for captive use in its sister concern or as per agreement stated in Power purchase cum wheeling and Banking Agreement. In this Transmission charges, Wheeling Charges have to be paid by the wind turbine generator and losses are to be deducted as per the voltage levels. If after the captive use, if energy remain unutilized than this unutilized energy be termed as the Banked energy and must be paid to the consumer as per terms and condition mentioned in the agreement.

1.3 Wheeling and banking Agreement: Energy injected by Wind turbine generator is used for captive use in its sister concern or as per agreement stated in wheeling and Banking Agreement. In this Transmission charges, Wheeling Charges have to be paid by the wind turbine generator and losses are to be deducted as per the voltage levels. If after the captive use, if energy remain unutilized than this unutilized energy be termed as the Banked energy and must be paid to the consumer as per terms and condition mentioned in the agreement.

1.4 Renewable Energy Certificate Mechanism: In this agreement wind turbine generator sales energy to the utility as per the pool rate and also by selling Renewable Energy certificates. One energy certificate equals to 1Kwh.

II. Availability Based Tariff(ABT) Mechanism

To deal with the problems arises due to grid frequency. A new tariff scheme: Availability Based Tariff (ABT) was introduced in July 2002. ABT comprises of three components: 2.1. Capacity Charge 2.2. Energy Charge 2.3. Unscheduled Inter-change (UI) Charge.

A. Capacity Charge:

This component represents the fixed cost and is linked to the declared capacity/availability of the plant, i.e., its capability to deliver MWs on a day-by-day basis. The total amount payable to the generating company over a year towards the fixed cost would depend on the average availability of the plant over the year. In case the average actually achieved over the year is higher than the specified norm for plant availability, the generating company would get a higher payment and also get incentive. In case the average availability achieved is lower, the payment will be lower and given in the form of pro-rata basis. Hence, the scheme is named Availability Based Tariff.

B. Energy Charge:

This component of ABT comprises of the variable cost, i.e. the fuel cost(in case of thermal power plant Coal as the primary fuel and oil (HFO + LDO)as secondary fuel of the power plant for generating energy as per given schedule for the day. Therefore, this energy charge is not according to the actual generation but only for scheduled generation.

C. Unscheduled Interchange Charge:

In case there are deviations from schedule, this third component of ABT comes into picture. Deviations from schedule are determined in 15-minute time blocks through special metering. They are priced according to the system condition prevailing at that time. If the frequency is above 50 Hz (nominal frequency in Indian System), UI rate will be small and if it is below 50 Hz, it will be high. As long as the actual generation/withdrawal is according to the given schedule, the third component of ABT is zero. In case of over-drawl, beneficiary has to pay UI charge according to the frequency dependent rate specified. Beside promoting competition, efficiency and economy and leading to more economically viable power scenario, ABT has been able to pave way for high quality power with more reliability and availability through enhanced grid discipline. This UI component is having more relevance.

III. CASE STUDY

For the case studies we take data from Rajasthan Discoms for FY-10-11 & Fy-11-12 in order to illustrate UI implication on Distribution Utility and how wind energy penetration into the grid helps to reduce the UI implication on the Distribution Utilities.

In the state of Rajasthan preferential tariff for WTG (wind turbine generator) was as follows:-

(1) Fy-(10-11) -Rs 4.10 per Kwh

(2) Fy-(11-12) -Rs 4.46 per Kwh

We proposed a scenario that if sufficient green energy injected into the grid than it will definitely help in reducing UI implications on Utilities and help in improving the financial health of Utilities. If the proper mechanism will be developed than it will help in more green energy into the grid. This energy is injected into the grid with zero fuel cost. Here we take wind energy source ,which an important renewable energy source for state like Rajasthan and having scarcity of fossil fuels as comparison to other states of India,but ample wind energy potential. We proposed a system by which state may be benefited by increasing its wind power generation by injecting into the grid.

*(a).*The Table -4 illustrates the comparative implication of Average UI rate for actual system and of proposed scenario. Here the 15 minutes time blocks for the first day of months from FY-(10-11) and FY-(11-12) has been used for study. When the over drawl UI rate was greater than that of the wind tariff rates of Rs.4.10 per Kwh and Rs.4.46 per Kwh, we substitute these tariff in 15 minutes time blocks i.e when UI rates are below that of Rs.4.10 per Kwh & Rs.4.46 per Kwh,we substitute same UI rates and if UI rates are more than that of above WTG rates than ,we substitute same WTG rates.This scenario will help in knowing how much wind generation will be needed. So that the Utilities will not overdrawal from regional grid and pay additional UI rates. It seems from Figure -1 and Figure-2, average UI rate has reduced mostly for the months.

Table-3.1 Comparative Study for Actual Average UI(Rs./Kwh) V/S Wind Energy penetration into the Grid(Proposed)

First Day of Months for FY-10-11	**01-04-2010**	**01-05-2010**	**01-06-2010**	**01-07-2010**	**01-08-2010**	**01-09-2010**	**01-10-2010**	**01-11-2010**	**01-12-2010**	**01-01-2011**	**01-02-2011**	**01-03-2011**
Average UI rate after more Wind penetration into	3.57	3.15	3.10	2.95	0.727	1.49	2.33	1.34	2.32	1.84	3.64	1.99

the Grid (Rs./Kwh)*												
Actual Average UI rate(Rs./Kwh)	4.31	3.56	3.81	3.47	0.727	1.49	2.40	1.34	2.45	1.89	4.67	1.99
First Day of Months for FY-11-12	**01-04-2011**	**01-05-2011**	**01-06-2011**	**01-07-2011**	**01-08-2011**	**01-09-2011**	**01-10-2011**	**01-11-2011**	**01-12-2011**	**01-01-2012**	**01-02-2012**	**01-03-2012**
Average UI rate after more Wind penetration into the Grid (Rs./Kwh)*	2.98	2.48	1.76	2.85	3.42	2.01	4.02	2.69	4.12	1.48	3.40	3.59
Actual Average UI rate(Rs./Kwh)	3.32	2.95	1.76	3.20	4.37	2.01	5.40	2.75	6.07	1.49	3.72	4.12

Figure-3.1 1st day of Months V/s UI rate for FY-10-11

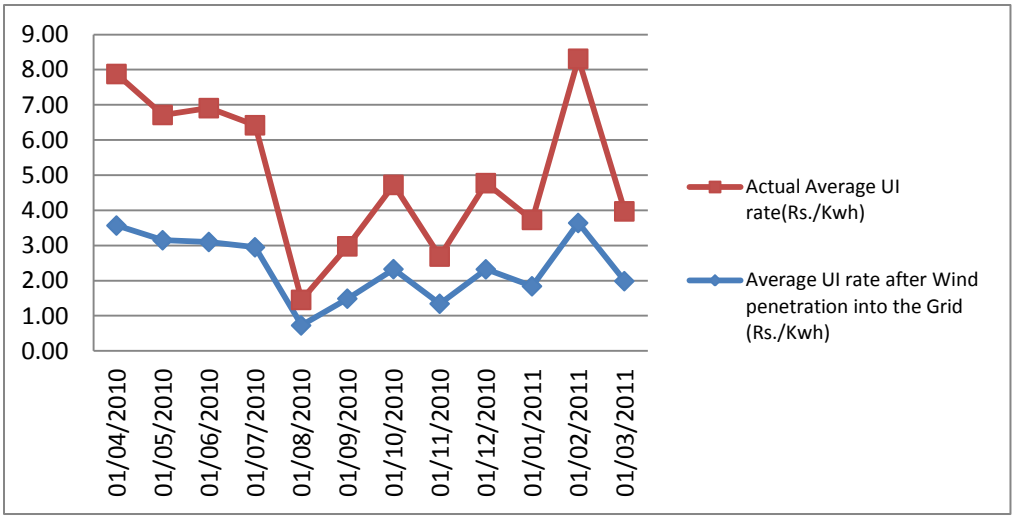
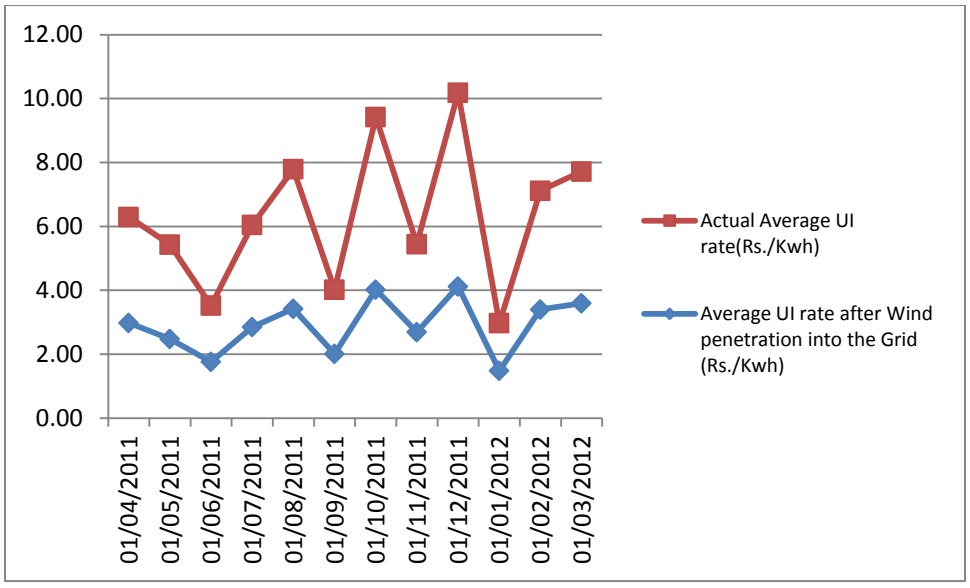


Figure-3.2 1st day of Months V/s UI rate for FY-11-12



*(b).*The Table-3 states the Over drawl(+) and Under drawl(-) units .The Rajasthan state distribution Utilities Overdraw 1196 LU's and Under drawl 72 LU's from the NREB.

Table-3.2 States the Over drawl (+) and Under drawl(-) units

First Day of Months for FY-10-11	**01-04-2010**	**01-05-2010**	**01-06-2010**	**01-07-2010**	**01-08-2010**	**01-09-2010**	**01-10-2010**	**01-11-2010**	**01-12-2010**	**01-01-2011**	**01-02-2011**	**01-03-2011**
OD(+) LU	28	114	43	143	44	120	81	62	87	160	184	125
UD(-) LU	-10	-10	-20	0	-12	-1	-4	-13	0	0	0	-2
First Day of Months for FY-11-12	**01-04-2011**	**01-05-2011**	**01-06-2011**	**01-07-2011**	**01- 08-2011**	**01-09-2011**	**01-10-2011**	**01-11-2011**	**01-12-2011**	**01-01-2012**	**01-02-2012**	**01-03-2012**
OD(+) LU	84	100	57	105	117	75	55	96	49	112	115	113
UD(-) LU	-19	-5	-8	-3	0	0	-12	-1	-8	-2	-2	0

Figure-3.3 Shows trends of the Over drawl (+) and Under drawl(-) units For Fy-10-11

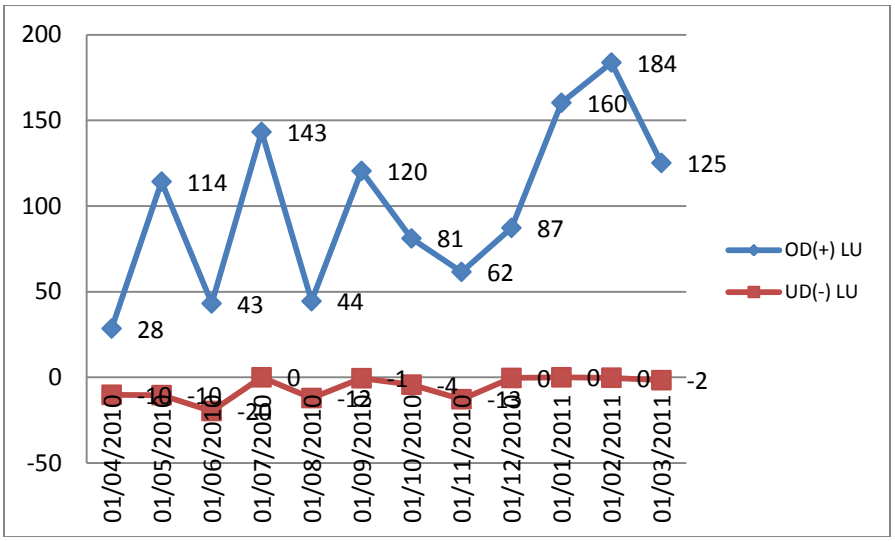
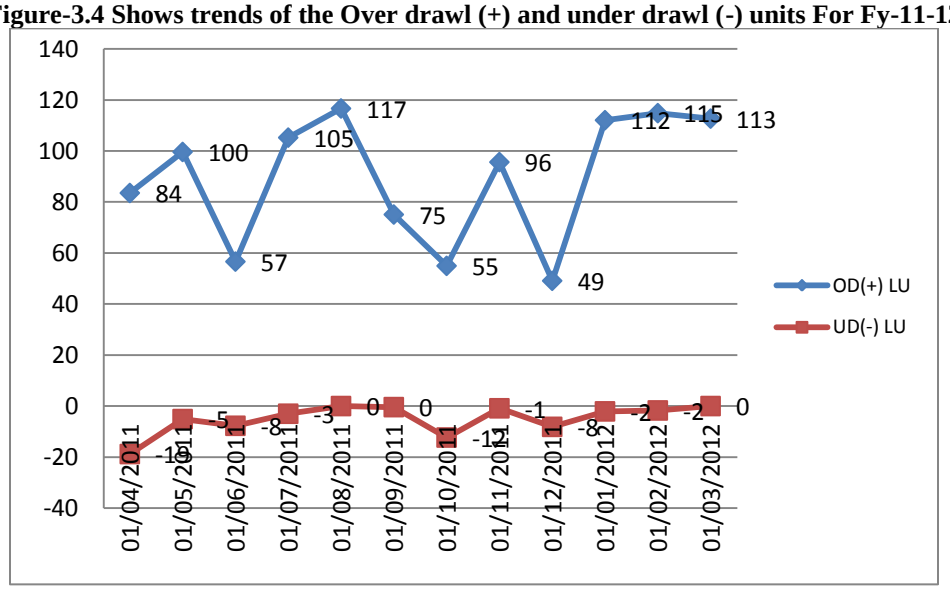


Figure-3.4 Shows trends of the Over drawl (+) and under drawl (-) units For Fy-11-12



IV. Results

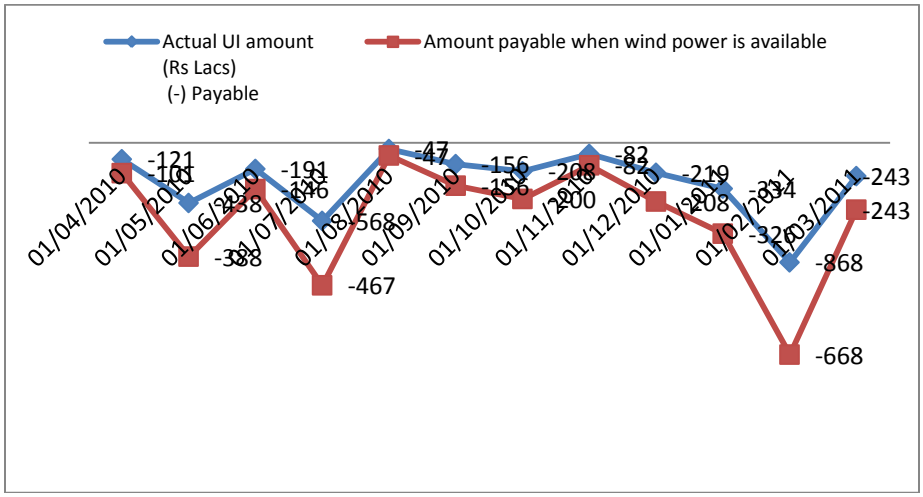
As from Table-4 it has been clear, when wind energy has been penetrated,than average UI rate (wind tariff @ Rs 4.10/Kwh or UI rate equal or below that of Rs.4.10/Kwh) implication on utilities will definitely will reduced to certain extent..

Table-4.1 States the Actual UI amount Payable (-) and Amount payable when more wind generation is available (-)(Proposed) the For Fy-10-11

First Day of Months for FY-10-11	01-04-2010	01-05-2010	01-06-2010	01-07-2010	01-08-2010	01-09-2010	01-10-2010	01-11-2010	01-12-2010	01-01-2011	01-02-2011	01-03-2011
Actual UI amount (Rs Lacs) (-) Payable	-121	-438	-191	-568	-47	-156	-208	-82	-219	-334	-868	-243
Amount (Rs.Lacs)payable when more wind power is available(proposed)	-101	-388	-146	-467	-47	-156	-200	-82	-208	-326	-668	-243

It seems that when wind penetration is introduced into the grid, it helps in mitigate the UI implication on the Distribution Utility and help in the grid security.

Figure-4.1 Shows trends of Actual UI amount Payable (-) and Amount payable when more wind generation is available (-) (Proposed) for Fy-11-12

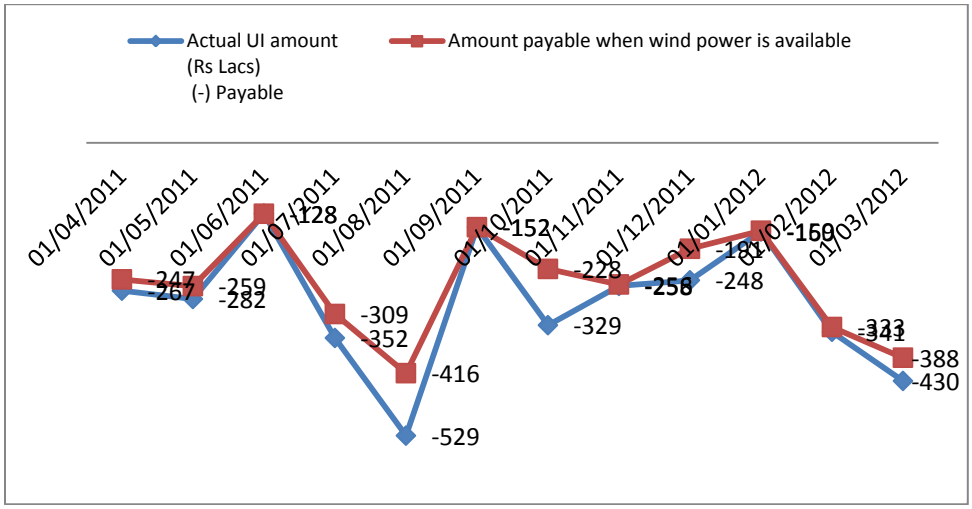


As from Table-4.1 it has been clear, when wind energy has been penetrated at the average tariff rate* (wind tariff @ Rs 4.46/Kwh+UI rate equal or below that of Rs.4.46/Kwh) as comparison of over drawl UI rate for the distribution utilities.

Table-4.1 States the Actual UI amount Payable (-) and Amount payable when more wind generation is available (-)(Proposed) for Fy-11-12

First Day of Months for FY-11-12	01-04-2011	01-05-2011	01-06-2011	01-07-2011	01-08-2011	01-09-2011	01-10-2011	01-11-2011	01-12-2011	01-01-2012	01-02-2012	01-03-2012
Actual UI amount (Rs Lacs) (-) Payable	-267	-282	-128	-352	-529	-152	-329	-258	-248	-160	-341	-430
Amount (Rs.Lacs)payable* when more wind power is available	-247	-259	-128	-309	-416	-152	-228	-256	-191	-159	-333	-388

Figure-4.2 Shows trends of Actual UI amount Payable (-) and Amount payable when wind generation is available (-) (Proposed) for Fy-11-12



Hence it may be concluded that wind energy is the important renewable source of energy, which when penetrate into the grid it will definitely reduce burden of UI on distribution utilities.

V. Conclusion

Wind energy is the important renewable source of energy as it zero fuel cost energy. It is the high time to think upon green source of energy and energy resources available within the states. If the States are having there more generation capacity than they will not interested in overdrawing power from regional grids under lower frequency scenario. It will again help in maintaining grid discipline and grid security. Wind energy often not able to be scheduled, which is main disadvantage adhere to this energy source. This renewable source of energy helps in reducing carbon content in the nature and reduces dependency on fossil fuels. To overcome the problem of scheduling of wind energy, it must be bundled with the firm power sources. So can be traded into the real-time market and helpful in injecting more green power into the grid and cheap energy.

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