REWS & TI CORRECTION METHODS
Vs
REAL PERFORMANCE TRENDS

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DATA AND SCOPE

DATASETS

✓DATASET 1 AND 4 INTERNAL DDBB ARE ANALYSED

✓ONLY DATA FROM VALID SECTOR IS CONSIDERED

ANALYSIS

✓COMPARATION BETWEEN OBSERVED REAL PERFORMANCE TRENDS AND CORRECTIONS METHODS.

✓DIFFERENCES IN ACTUAL ENERGY YIELD Vs RESOURCE ASSESSMENT ENERGY YIELD ESTIMATION (BEFORE AND AFTER APLYING CORRECTION METHODS).

OBSERVED ACTUAL POWER CURVE TRENDS
Vs
CORRECTION METHODS

DATA SET 1

→ **Wind Speed above hub height obtained by Lidar measurements.**

ANKLE: 1343 data

ROTOR EQUIVALENT WIND SPEED AND TI CORRECTIONS

TI \ $f_{r,RSD}$	0.98	0.99	1	1.01	1.02	Average
6-8	-7%	-4%	-2%	1%	5%	-1%
8-10	-7%	-3%	0%	2%	5%	0%
10-12	-5%	-2%	1%	4%	7%	2%
12-14	-3%	-1%	2%	5%	8%	3%
14-16		0%	4%	6%	10%	5%
16-18		2%	5%	8%	12%	7%
18-20	2%	5%	8%	11%	14%	9%
Average	-6%	-2%	1%	4%	8%	

ACTUAL POWER

TI \ $f_{r,RSD}$	0.98	0.99	1	1.01	1.02	Average
6-8	-7%	-3%	-2%	-3%	2%	-2%
8-10	-7%	-3%	-3%	-1%	-2%	-3%
10-12	-1%	0%	-2%	0%	-1%	-1%
12-14	2%	4%	1%	0%	-1%	1%
14-16		-3%	-2%	3%	-1%	0%
16-18		1%	3%	6%	5%	5%
18-20	-5%	7%	11%	9%	-2%	5%
Average	-5%	-1%	-1%	1%	0%	

KNEE: 1040 data

ROTOR EQUIVALENT WIND SPEED AND TI CORRECTIONS

TI \ $f_{r,RSD}$	0.98	0.99	1	1.01	1.02	Average
6-8		-2%	0%	2%	4%	0%
8-10		-2%	0%	2%	5%	0%
10-12		-2%	0%	2%	4%	0%
12-14		-2%	-1%	1%	6%	0%
14-16		-2%	-1%	2%	3%	-1%
16-18		-2%	-3%	2%		-2%
18-20		-4%	-3%			-3%
Average		-2%	-1%	1%	4%	

ACTUAL POWER

TI \ $f_{r,RSD}$	0.98	0.99	1	1.01	1.02	Average
6-8		-3%	-2%	-4%	-2%	-3%
8-10		0%	-3%	-1%	0%	-2%
10-12		-5%	-4%	-2%	0%	-4%
12-14		-6%	-3%	-2%	-2%	-3%
14-16		-3%	-4%	-2%	-3%	-3%
16-18		-2%	-4%	2%		-1%
18-20		-7%	-2%			-5%
Average		-4%	-3%	-2%	0%	

BRN CASE 1

→ **Wind Speed above hub height obtained by Lidar measurements.**

ANKLE: 764 data

ROTOR EQUIVALENT WIND SPEED AND TI CORRECTIONS

TI \ $f_{r,RSD}$	0.97	0.98	0.99	1	1.01	1.02	1.03	1.04	1.05	1.06	Average
0-2	-14%	-7%	-6%	-3%	0%						-6%
2-4	-16%	-12%	-9%	-4%	-1%	4%	7%	12%	14%	19%	-5%
4-6	-13%	-13%	-7%	-3%	1%	4%	8%	12%	16%	20%	0%
6-8	-14%	-10%	-6%	-2%	0%	5%	9%	14%	15%	23%	2%
8-10	-10%	-9%	-4%	-1%	2%	6%	10%	15%	19%	21%	5%
10-12	-11%	-7%	-2%	1%	4%	10%	13%	18%	21%	25%	9%
Average	-14%	-11%	-6%	-2%	1%	5%	9%	15%	18%	23%	

ACTUAL POWER

TI \ $f_{r,RSD}$	0.97	0.98	0.99	1	1.01	1.02	1.03	1.04	1.05	1.06	Average
0-2	-35%	-11%	-16%	-11%	-2%						-17%
2-4	-27%	-25%	-22%	-13%	-13%	-10%	-16%	-12%	-19%	-6%	-18%
4-6	-25%	-29%	-22%	-13%	-19%	-14%	-13%	-6%	-15%	-11%	-17%
6-8	-26%	-24%	-15%	-11%	-16%	-10%	-16%	-7%	-24%	-6%	-14%
8-10	-13%	-29%	-1%	-7%	-11%	-11%	-11%	-16%	-9%	-6%	-9%
10-12	-30%	-20%	3%	-10%	-3%	-9%	-10%	-9%	2%	-5%	-6%
Average	-26%	-26%	-14%	-11%	-13%	-11%	-14%	-10%	-11%	-7%	

KNEE: 752 data

ROTOR EQUIVALENT WIND SPEED AND TI CORRECTIONS

TI \ $f_{r,RSD}$	0.98	0.99	1	1.01	Average
0-2	1%	3%	5%		2%
2-4	1%	2%	3%	4%	2%
4-6	0%	1%	2%	4%	2%
6-8	-1%	1%	2%	3%	1%
8-10	-1%	0%	1%	2%	0%
10-12	-2%	-2%	-1%	0%	-1%
12-14	-3%	-2%	-1%	-1%	-2%
Average	0%	0%	1%	3%	

ACTUAL POWER

TI \ $f_{r,RSD}$	0.98	0.99	1	1.01	Average
0-2	4%	3%	8%		4%
2-4	-1%	2%	1%	2%	1%
4-6	-2%	1%	2%	3%	2%
6-8	-1%	3%	3%	1%	2%
8-10	1%	3%	2%	2%	2%
10-12	-2%	3%	3%	4%	3%
12-14	1%	-3%	4%	0%	1%
Average	0%	2%	2%	2%	

BRN CASE 2

→ **Wind Speed above hub height obtained by considering a wind profile constant throught the swept area (alpha calculated between lower tip and hub)**

ANKLE: 1630 data

ROTOR EQUIVALENT WIND SPEED AND TI CORRECTIONS

TI \ shear	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01	
2-4		-5%		-3%		-1%	-1%	1%	2%	4%	1%
4-6	-3%	-3%	-3%	-3%	-3%	-1%	-1%	0%	2%	3%	-1%
6-8	-2%	-2%	-2%	-2%	-1%	-1%	0%	1%	2%	4%	-1%
8-10	-1%	-1%	-1%	-1%	0%	0%	1%	2%	3%	4%	0%
10-12	0%	0%	0%	0%	1%	1%	2%	3%	4%	6%	1%
12-14	1%	1%	1%	2%	2%	3%	3%	5%	6%	7%	2%
14-16	3%	3%	3%	3%	4%	4%	5%				4%
16-18	5%	4%	5%	5%	6%	5%	7%				6%
18-20	4%	6%	7%	7%	7%						7%
Average	0%	0%	0%	1%	1%	1%	2%	2%	4%	5%	

ACTUAL POWER

TI \ shear	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01	
2-4		-4%		-9%		-5%	-12%	-13%	-18%	-17%	-13%
4-6	5%	-3%	-4%	-7%	-4%	-7%	-10%	-11%	-19%	-10%	-8%
6-8	-4%	2%	-7%	-10%	-3%	-5%	-9%	-11%	-6%	-11%	-6%
8-10	4%	-3%	0%	3%	-2%	-5%	-8%	-9%	-10%	-11%	-3%
10-12	7%	5%	2%	2%	2%	-3%	-6%	-8%	-7%	-14%	1%
12-14	9%	8%	4%	3%	-1%	1%	-8%	-5%	-9%	-17%	2%
14-16	18%	11%	9%	7%	0%	-3%	-21%				4%
16-18	20%	15%	8%	-1%	2%	-13%	-2%				1%
18-20	-17%	17%	-8%	2%	2%						-2%
Average	7%	4%	2%	2%	-1%	-4%	-9%	-9%	-10%	-14%	

KNEE: 746 data

REWS TI CORRECTIONS

TI \ shear	0.10	0.15	0.20	0.25	0.30	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	1.00	
2-4		3%	1%			2%
4-6	3%	2%	2%	2%	1%	2%
6-8	1%	1%	1%	1%	1%	1%
8-10	0%	0%	0%	0%	0%	0%
10-12	-2%	-2%	-2%	-2%	-2%	-2%
12-14	-3%	-3%	-2%	-3%	-3%	-3%
14-16	-5%	-5%	-5%	-6%	-5%	-5%
Average	-1%	0%	0%	-1%	-1%	

ACTUAL POWER

TI \ shear	0.10	0.15	0.20	0.25	0.30	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	1.00	
2-4		-1%	0%			-1%
4-6	-2%	-2%	0%	0%	-2%	-1%
6-8	-4%	-3%	-3%	-3%	1%	-3%
8-10	-3%	-2%	-3%	-4%	-6%	-3%
10-12	-4%	-3%	-3%	-4%	-5%	-3%
12-14	-1%	-1%	-2%	-3%	-7%	-2%
14-16	-1%	0%	-1%	-5%	-1%	-2%
Average	-3%	-2%	-3%	-4%	-4%	

BRN CASE 3

→ **Wind Speed above hub height obtained by considering a wind profile constant throught the swept area (alpha calculated between lower tip and hub)**

ANKLE: 176 data

ROTOR EQUIVALENT WIND SPEED AND TI CORRECTIONS						
TI \ Shear	0.10-0.15	0.15-0.20	0.20-0.25	0.25-0.30	0.30-0.35	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	1.00	
12-14	0%			1%	1%	1%
14-16	2%		2%		3%	2%
16-18	4%	4%	4%	4%	4%	4%
18-20		5%	5%	6%		5%
Average	2%	3%	3%	3%	2%	

ACTUAL POWER						
TI \ Shear	0.10-0.15	0.15-0.20	0.20-0.25	0.25-0.30	0.30-0.35	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	1.00	
12-14	-2%			1%	-2%	-2%
14-16	-1%		7%		-5%	-4%
16-18	7%	-1%	10%	12%	-6%	5%
18-20		9%	20%	4%		10%
Average	-1%	-3%	7%	3%	-6%	

KNEE: 672 data

ROTOR EQUIVALENT WIND SPEED AND TI CORRECTIONS					
TI \ Shear	0.10-0.15	0.15-0.20	0.20-0.25	0.25-0.30	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	
10-12	-1%	-1%	-2%	-2%	-1%
12-14	-3%	-3%	-3%	-4%	-3%
14-16	-5%	-5%	-6%	-5%	-5%
16-18	-7%	-7%	-8%	-6%	-7%
18-20	-9%	-9%	-9%	-8%	-9%
20-22	-11%	-11%	-11%	-11%	-11%
22-24	-14%	-13%	-13%	-14%	-13%
24-26		-15%	-15%	-17%	-15%
Average	-6%	-7%	-7%	-7%	

ACTUAL POWER					
TI \ Shear	0.10-0.15	0.15-0.20	0.20-0.25	0.25-0.30	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	
10-12	-13%	-8%	-8%	-7%	-8%
12-14	-7%	-7%	-7%	-5%	-7%
14-16	-5%	-7%	-8%	-8%	-7%
16-18	-7%	-9%	-8%	-11%	-8%
18-20	-6%	-7%	-7%	-10%	-8%
20-22	-7%	-11%	-15%	-13%	-12%
22-24	-12%	-13%	-14%	-24%	-15%
24-26		-13%	-17%	-21%	-16%
Average	-7%	-9%	-9%	-10%	

BRN CASE 4

→ **Wind Speed above hub height obtained by considering a wind profile constant throught the swept area (alpha calculated between lower tip and hub)**

ANKLE: 274 data

ROTOR EQUIVALENT WIND SPEED AND TI CORRECTIONS

TI \ Shear	0.05-0.10	0.10-0.15	0.15-0.20	0.20-0.25	0.25-0.30	0.30-0.35	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	1.00	1.00	
4-6	-3%	-3%	-4%		-3%	-2%	-3%
6-8		-2%	-3%	-2%	-2%	-1%	-2%
8-10	-1%	-1%	-2%	-1%	-1%	-1%	-1%
10-12	0%	0%	0%	0%	0%	1%	0%
12-14	1%	1%	1%	1%	1%	1%	1%
14-16	3%	2%	2%	2%	3%		3%
Average	0%	0%	0%	0%	-1%	0%	

ACTUAL POWER

TI \ Shear	0.05-0.10	0.10-0.15	0.15-0.20	0.20-0.25	0.25-0.30	0.30-0.35	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	1.00	1.00	
4-6	-10%	-14%	-17%		-15%	-13%	-16%
6-8		-17%	-13%	-14%	-10%	-14%	-14%
8-10	-19%	-9%	-16%	-10%	-9%	-10%	-11%
10-12	-4%	-1%	-4%	-6%	-4%	-13%	-6%
12-14	-15%	-8%	-5%	-2%	-6%	-4%	-8%
14-16	-6%	-11%	-3%	-11%	-3%		-8%
Average	-10%	-9%	-10%	-10%	-8%	-12%	

KNEE: 1543 data

ROTOR EQUIVALENT WIND SPEED AND TI CORRECTIONS

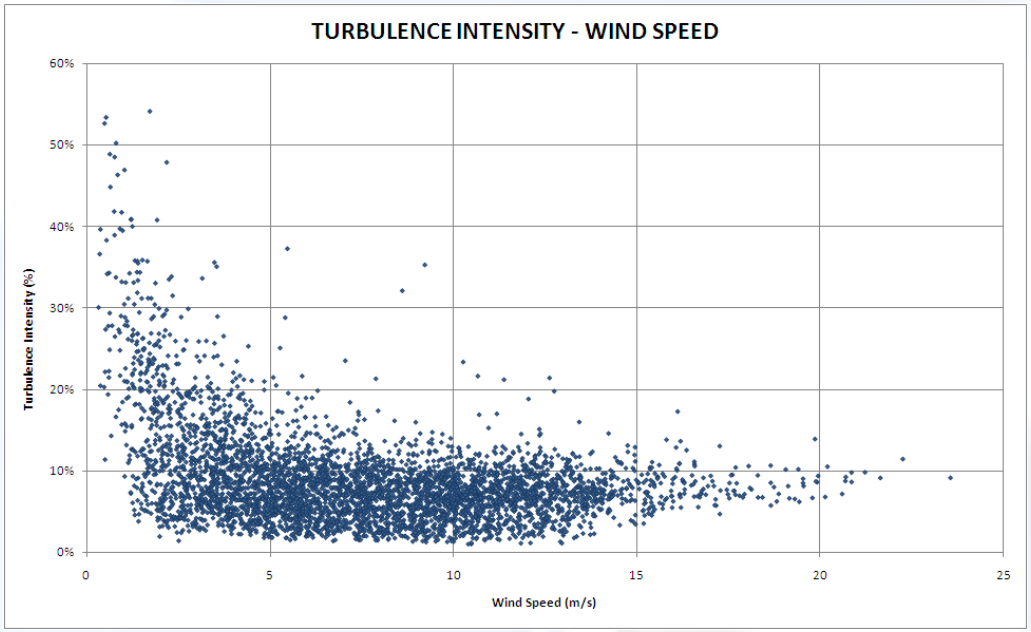
TI \ Shear	0.05-0.10	0.10-0.15	0.15-0.20	0.20-0.25	0.25-0.30	0.30-0.35	0.35-0.40	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	1.00	1.00	1.01	
6-8		1%	1%	0%	1%			1%
8-10	0%	1%	0%	0%	1%	1%		0%
10-12	-2%	-1%	-1%	-1%	-1%	0%		-1%
12-14	-2%	-2%	-2%	-2%	-3%	-3%	-4%	-2%
14-16	-2%	-4%	-4%	-4%	-4%	-4%	-6%	-4%
16-18	-7%	-6%	-6%	-6%	-6%	-6%		-6%
18-20		-8%	-8%	-7%	-8%	-8%		-8%
20-22		-12%	-10%	-9%	-9%	-9%	-9%	-9%
22-24			-10%	-12%	-11%	-11%	-13%	-11%
24-26			-14%	-12%	-13%	-14%	-13%	-13%
26-28				-15%	-14%	-15%	-12%	-14%
Average	-2%	-3%	-3%	-3%	-4%	-6%	-9%	

ACTUAL POWER

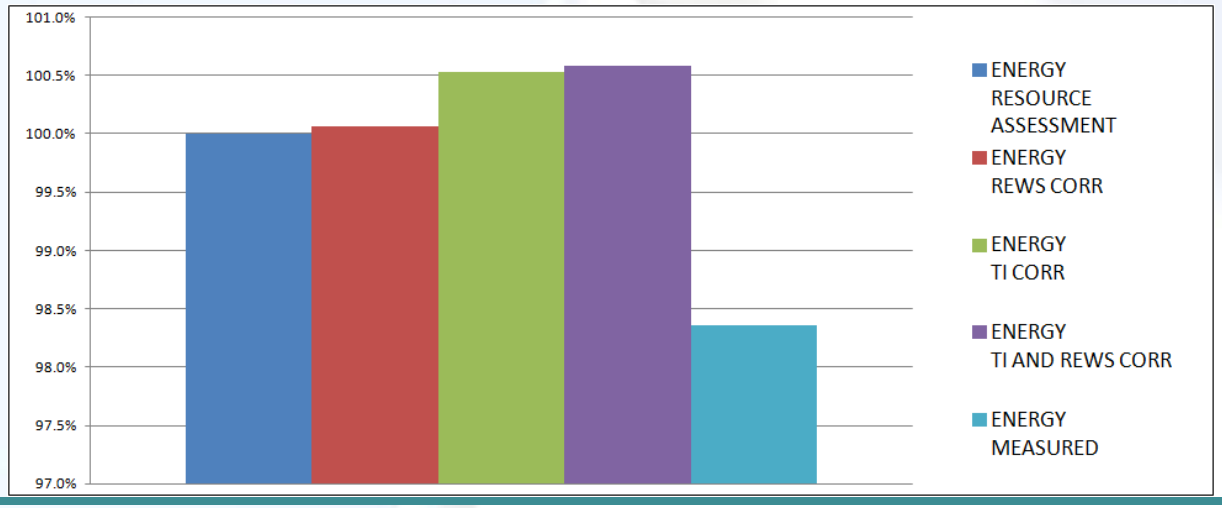
TI \ Shear	0.05-0.10	0.10-0.15	0.15-0.20	0.20-0.25	0.25-0.30	0.30-0.35	0.35-0.40	Average
TI \ $f_{r,RSD}$	1.00	1.00	1.00	1.00	1.00	1.00	1.01	
6-8		0%	0%	-3%	0%			-1%
8-10	-3%	-2%	-2%	-2%	-4%	-3%		-2%
10-12	-4%	-3%	-2%	-2%	-2%	-7%		-2%
12-14	-4%	-3%	-3%	-3%	-3%	-6%	-10%	-3%
14-16	-3%	-4%	-4%	-4%	-5%	-6%	-9%	-4%
16-18	-11%	-6%	-5%	-6%	-6%	-8%		-6%
18-20		-7%	-7%	-6%	-9%	-10%		-7%
20-22		-4%	-9%	-9%	-10%	-11%	-10%	-9%
22-24			-10%	-11%	-11%	-14%	-18%	-12%
24-26			-11%	-9%	-14%	-15%	-19%	-14%
26-28				-19%	-22%	-20%	-15%	-19%
Average	-4%	-4%	-4%	-4%	-5%	-9%	-13%	

ACTUAL ENERGY YIELD
Vs
RESOURCE ASSESSMENT ENERGY YIELD ESTIMATION

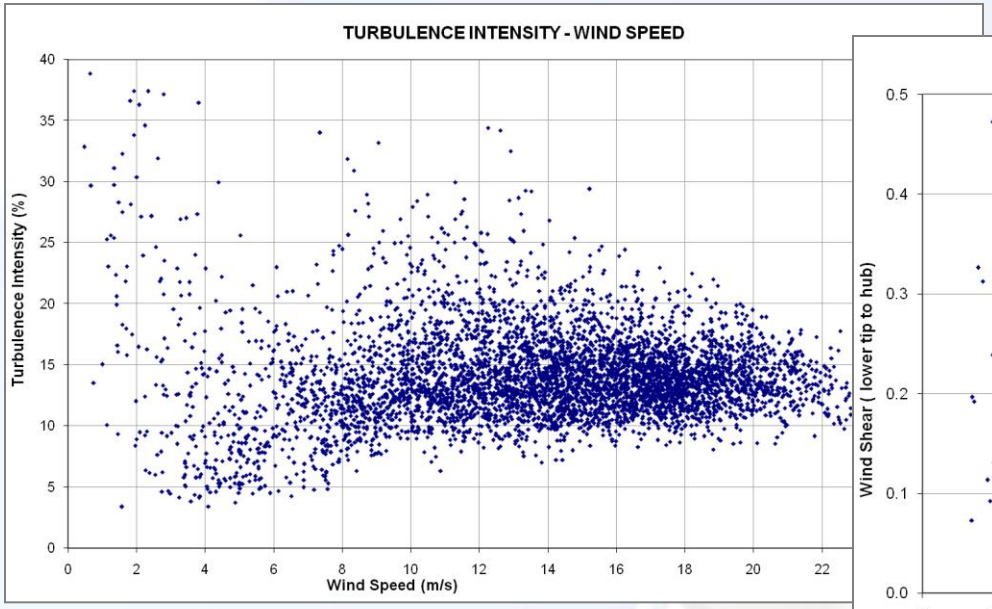
BRN CASE 1

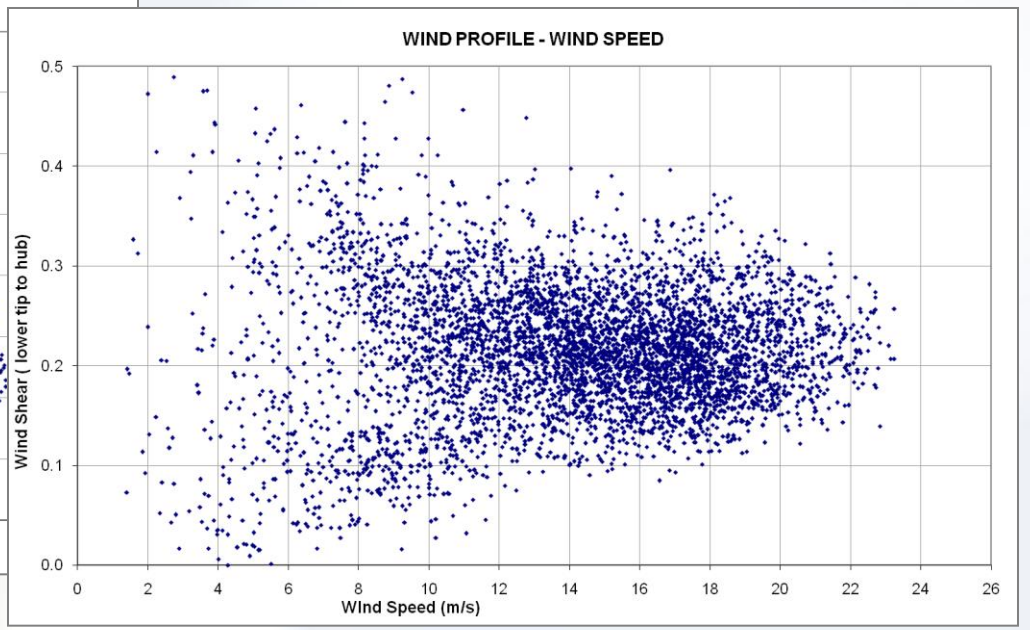


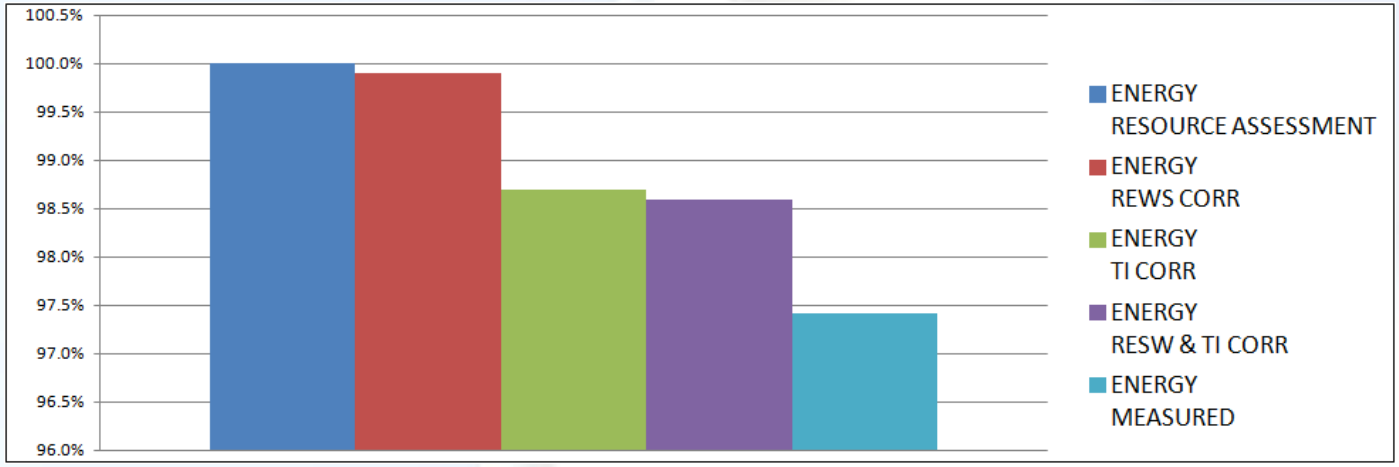
V (m/s)	$f_{r,RSD}$
3	1.05
4	1.03
5	1.02
6	1.01
7	1.00
8	1.00
9	1.00
10	1.00
11	1.00
12	1.00
13	0.99
14	1.00
15	1.00
16	1.00
17	1.00
18	1.00
19	1.00
20	1.00
21	0.99



BRN CASE 4


TURBULENCE INTENSITY - WIND SPEED
Turbulenece Intensity (%)
Wind Speed (m/s)
0
5
10
15
20
25
30
35
40
0
2
4
6
8
10
12
14
16
18
20
22


WIND PROFILE - WIND SPEED
Wind Shear (lower tip to hub)
WInd Speed (m/s)
0.0
0.1
0.2
0.3
0.4
0.5
0
2
4
6
8
10
12
14
16
18
20
22
24
26


100.5%
100.0%
99.5%
99.0%
98.5%
98.0%
97.5%
97.0%
96.5%
96.0%
ENERGY RESOURCE ASSESSMENT
ENERGY REWS CORR
ENERGY TI CORR
ENERGY RESW & TI CORR
ENERGY MEASURED

CONCLUSION

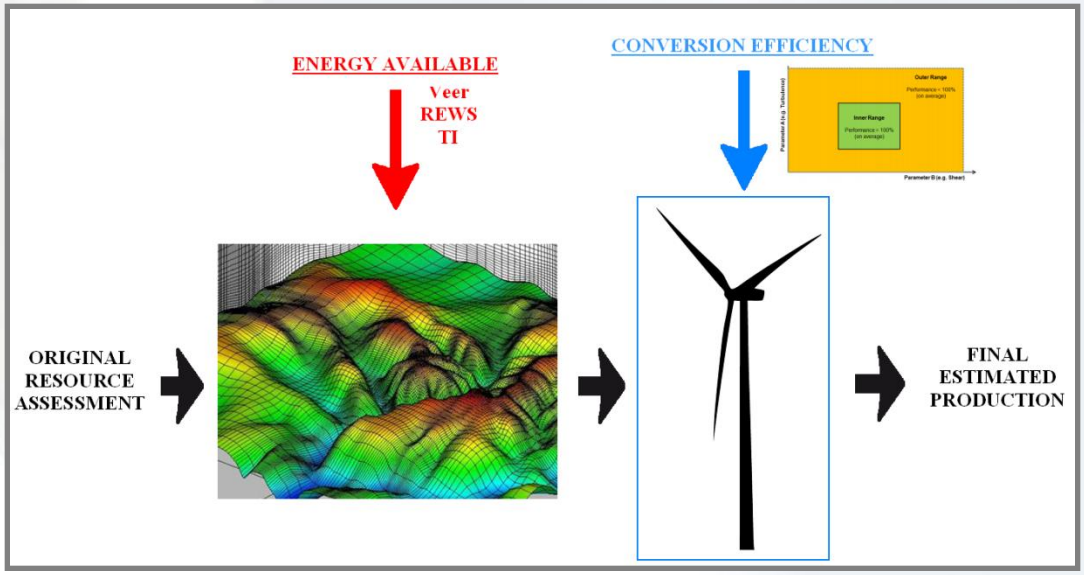
✓REWS AND TI ADJUSTMENTS SEEM TO FIT WITH THE OBSERVED REAL PERFORMANCE TRENDS, SPEFICALLY IN THOSE SITES WITH EXTREME CONDITIONS AND SIGNIFICANT DATA AVAILABLE.

✓DATA SETS WITH WIND SPEED MEASUREMENTS ABOVE HUB ARE NEEDED TO VALIDATE REWS CORRECTION METHOD.

✓THE DIFFERENCES IN ENERGY YIELD DUE TO THE APPLICATION OF THESE CORRECTION METHODS ARE SIGNIFICANT (PARTICULARLY TI).

✓THESE <u>TYPE A</u> EFFECTS ARE NOT ENOUGH TO BRIDGE THE WHOLE GAP BETWEEN ESTIMATED PRODUCTION AND ACTUAL ENERGY OUTPUT. CONVERSION EFFICIENCY EFFECTS SHOULD ALSO BE CONSIDERED:

- ✓ <u>TYPE B</u> ADJUSTMENTS (HIGHLY COMPLICATED).
- ✓ <u>INNER&OUTER RANGE</u> TO BE DEFINED, DEPENDENT ONLY OF THE WT RESPONSE (EASY TO IMPLEMENT).



THANK YOU FOR YOUR ATTENTION

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