Sandia, 2007 Wind Turbine Reliability Workshop

A Financial Perspective on Turbine Reliability

Larry Barr
enXco Service Corporation

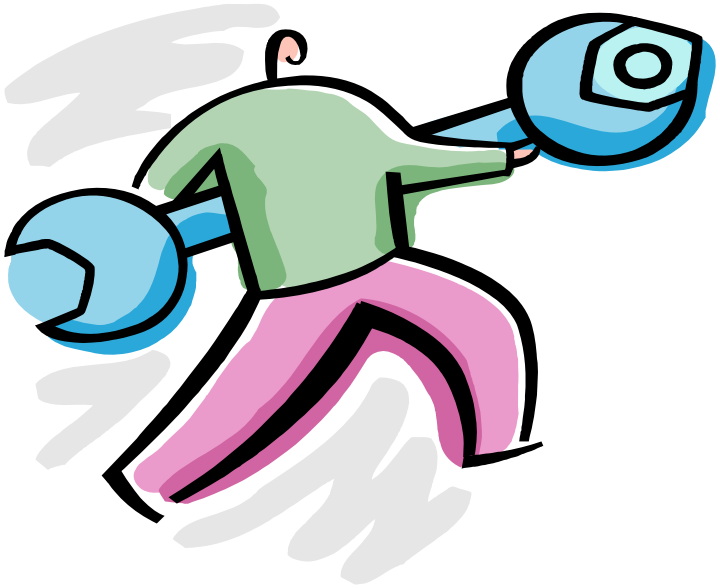
- **Developer, Owner, Third Party O&M Provider**
- **In business for 20 years**
- **> 4,000 WTG's totaling >2,000MW**
- **>200 employees**
- **Experience with > 24 WTG models & 14 mfgrs.**
- **In-house Engineering, Purchasing, Training, QC**

“One Size Doesn’t Fit All”

- Typical 100 – 200 MW Wind Plant
- Modern Turbines 1MW – 2.5 MW
- Post Warranty
- 25% – 45% Capacity Factors

Reliability Cost Factors

- Scheduled Maintenance
- Unscheduled Maintenance
- Parts Usage
- Inventory
- Heavy Equipment Costs
- BOP expense
- Engineering
- Insurance Deductibles
- Lost Revenue



“Fixed Fee for Fixed Scope of work”

- WTG scheduled maintenance
- Consumables
- Performance reporting
- BOP and general management
- Inventory control
- 24/7 remote monitoring
- Some unscheduled maintenance labor

Reimbursable Expenses

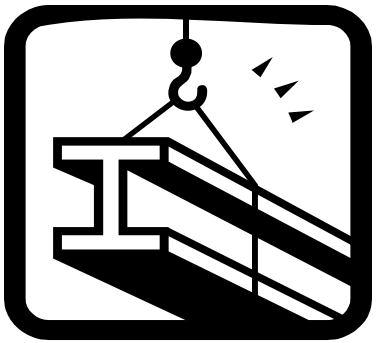
Billable Labor

- Well defined scope
- Rate Schedule established
- Provision for off-hours call outs

Parts Usage

Heavy Equipment

BOP

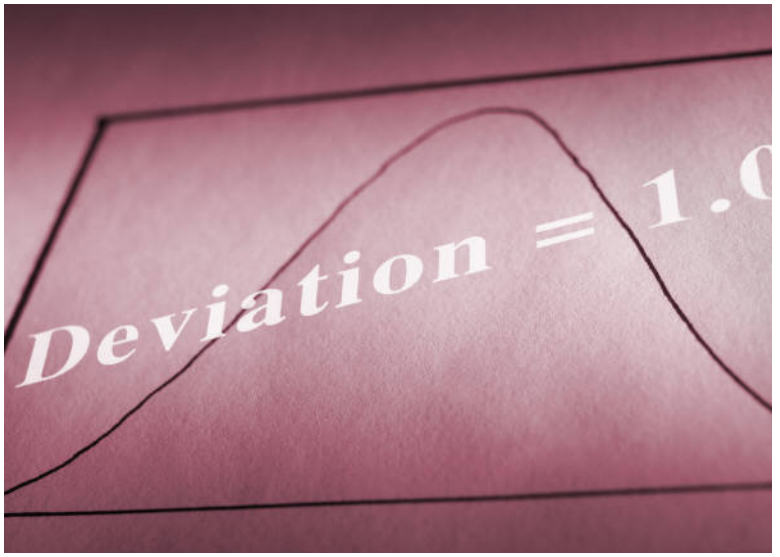


Other Cost Considerations

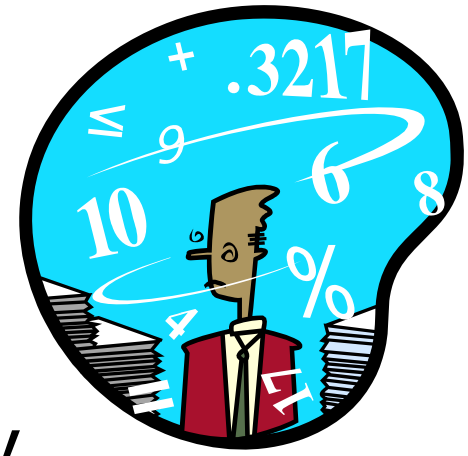
- Initial Inventory Purchase
- Engineering
- Insurance Deductibles

Cost Control and Analysis Tools

- Budgets
- Failure Rate Analysis
- Payback Analysis
- Lost Revenue Analysis



Budgets



- Need to be Detailed
- Compared to “Actuals” Regularly
- Need to be revisited annually
- Unscheduled Mtce Estimates from Experts

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Tracking, Tracking and more Tracking

Failure Rate Analysis

- Track critical components
- Differentiate failure modes
- Document aging parameters

WTG	Component	Make	Model	S/N	Install Date	Retire Date	Install MWh	Retire MWh	Failure Mode	Comment
1	Gearbox	Flender	PEAS 4-000	123456	9/1/2005		0			
2	Gearbox	Flender	PEAS 4-000	654321	9/1/2005		0			
3	Gearbox	Flender	PEAS 4-000	987654	9/1/2005	8/25/2006	0	2543	Intermediate tooth chip	Warranty. First failure of this mode.
3	Gearbox	Flender	PEAS 2-000	100001	8/31/2006		2543			
1	Generator	ABB	A10099	9/A/100	9/1/2005		0			

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Hourly Wind Speed Distribution - Typical Midwest Site

M/S	Hours	Power Curve	Production
<4	587	0	-
4	561	34	19,074
5	649	98	63,602
6	767	194	148,798
7	838	327	274,026
8	1016	503	511,048
9	907	737	668,459
10	691	1029	711,039
11	669	1301	870,369
12	507	1449	734,643
13	405	1494	605,070
14	343	1500	514,500
15		1500	-
16		1500	-
17	125	1500	187,500
18	94	1500	141,000
19	57	1500	85,500
20	128	1500	192,000
	8,760		6,350,628
	8,344		5,217,654
	95%		82%

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M/S	Hours	Power Curve	Production	
<4	587	0	-	
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8	1016	503	511,048	
9	907	737	668,459	
10	691	1029	711,039	
11	669	1301	870,369	In the Money
12	507	1449	734,643	
13	405	1494	605,070	
14	343	1500	514,500	
15	241	1500	361,500	
16	175	1500	262,500	
17	125	1500	187,500	
18	94	1500	141,000	
19	57	1500	85,500	
20	128	1500	192,000	
	8,760		6,350,628	
	7,427		6,054,054	
	85%		95%	

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Climb Assist and Elevators

Higher degree of Safety – technicians that are less fatigued are less likely to be involved in accidents.

Reduced long term health impact – climbing is hard on knees, shoulders and other joints.

Climb Assist and Elevators

- **Employee retention** – older and more experienced technicians remain on the job longer, and the younger techs' appreciate the enhanced safety and reduced physical demands of the job.
- **Higher Quality & Higher availability** – the result of all of the above advantages.

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