

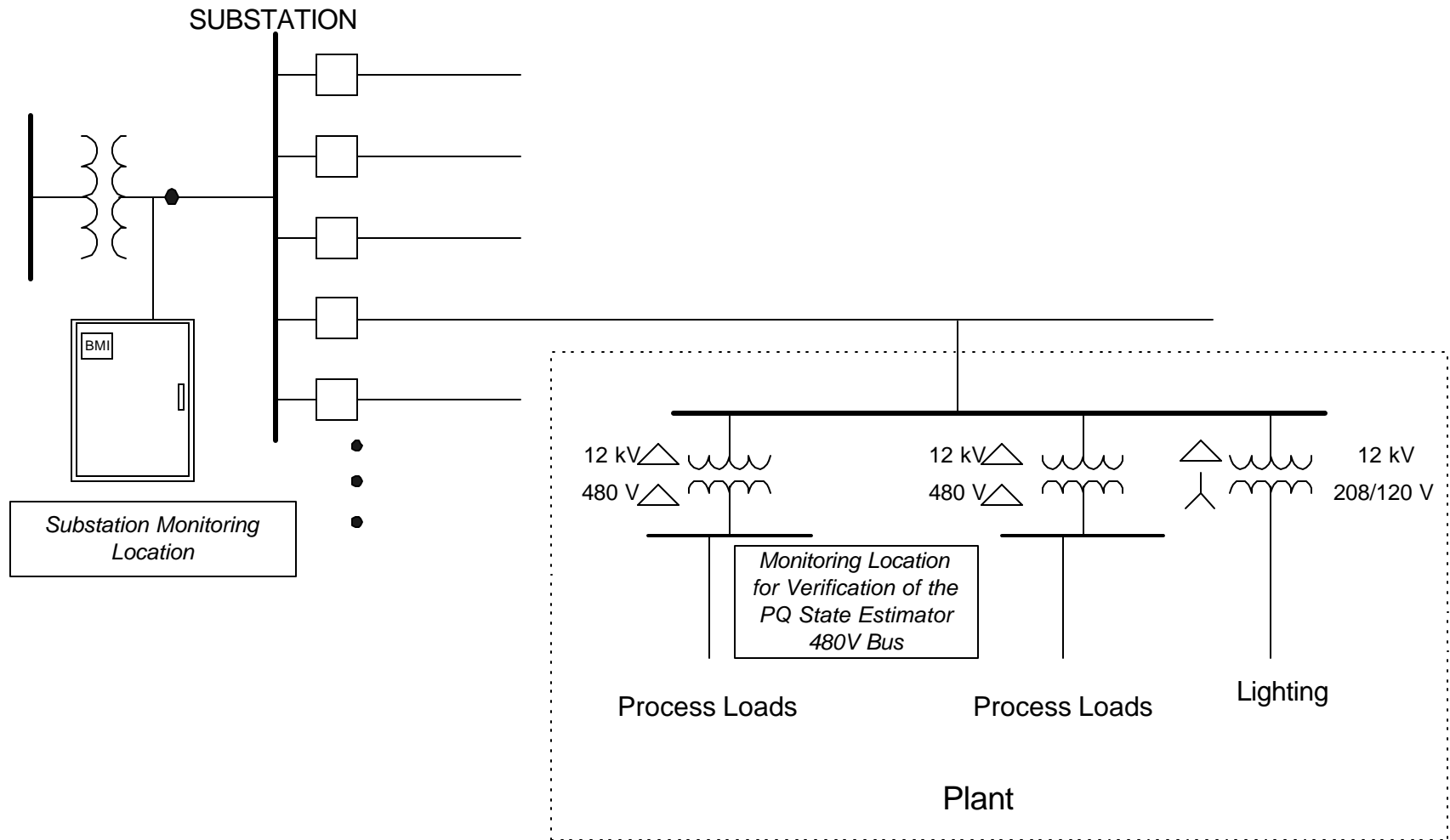
Evaluating the Economics of Custom Power Solutions

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Electrotek Concepts ®



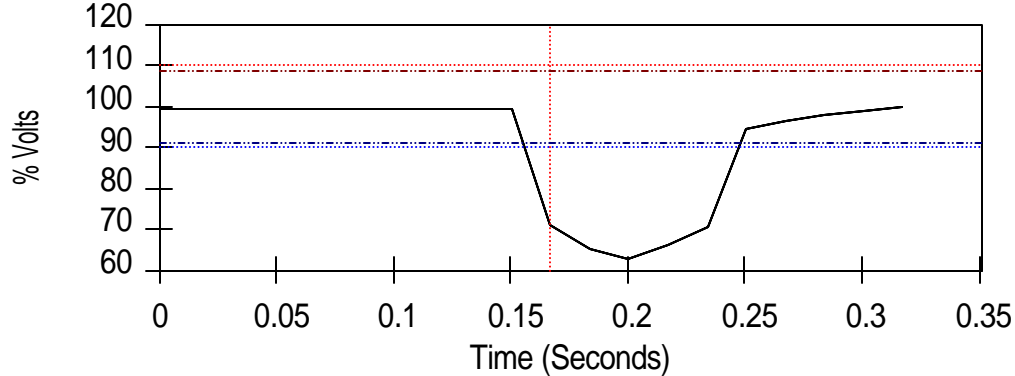
Example Situation



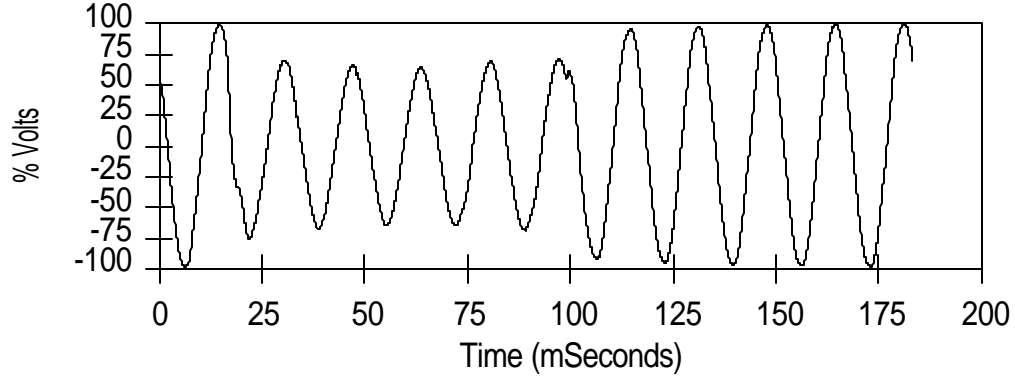
Example Event

Phase C-A Voltage
RMS Variation

Trigger



Duration	0.083 Sec
Min	62.96
Ave	82.36
Max	99.73
Ref Cycle	31273



Costs Of Voltage Sags

- Lost production/revenues
- Scrap
- Labor and overtime
- Equipment damage
- Other costs

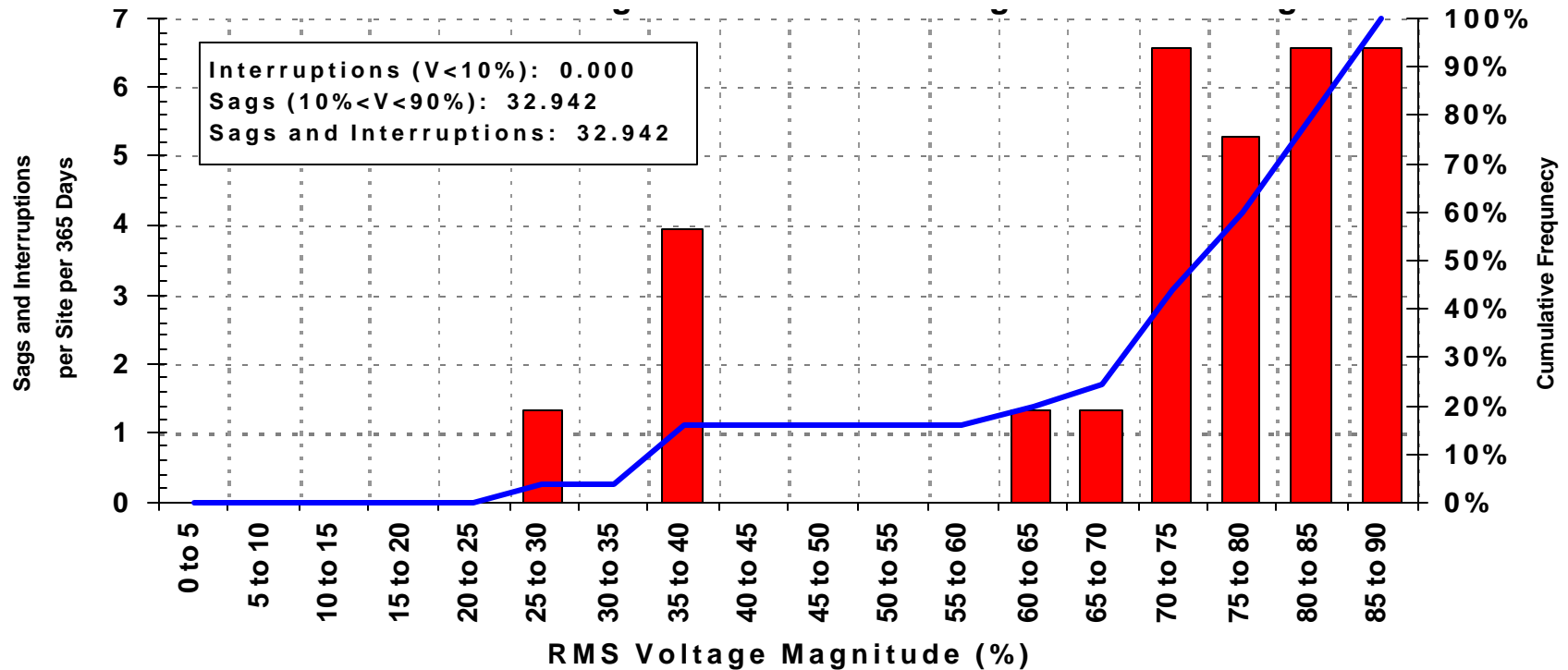
Analysis Process

- Characterize the environment
- Characterize the costs of PQ disturbances
- Characterize the effectiveness of various solutions
- Compare various alternatives

Monitored Events

Time Stamp	Phase	Magnitude (kV)	Magnitude (pu)	Duration (s)	Duration (cyc)
4/5/96 4:32:54 AM	C	7.099	0.891	0.017	1
4/10/96 2:12:57 AM	C	5.782	0.726	1.233	74
4/10/96 5:03:08 AM	A	5.670	0.712	0.083	5
4/10/96 5:22:46 AM	C	6.053	0.760	0.017	1
4/10/96 6:24:40 AM	B	4.860	0.610	0.067	4
4/10/96 7:14:01 AM	C	6.731	0.845	0.100	6
4/10/96 7:24:15 AM	C	6.551	0.822	0.083	5
4/10/96 7:29:41 AM	C	6.759	0.848	0.100	6
5/23/96 5:10:04 PM	C	8.778	1.102	0.017	1
5/25/96 7:25:06 PM	A	5.911	0.742	0.083	5
7/9/96 6:18:48 PM	A	6.262	0.786	0.100	6
7/13/96 10:00:48 AM	A	3.089	0.388	1.000	60
7/26/96 5:41:28 AM	A	2.123	0.266	0.567	34
8/27/96 2:55:08 PM	A	6.299	0.791	0.100	6
9/17/96 7:49:26 PM	B	5.815	0.730	0.133	8
9/22/96 5:20:47 PM	A	6.913	0.868	0.100	6
9/30/96 8:35:46 AM	C	3.044	0.382	0.100	6
10/14/96 12:35:51 PM	B	6.351	0.797	0.050	3
10/30/96 6:28:27 PM	C	5.824	0.731	0.017	1
11/8/96 11:56:19 AM	C	6.863	0.861	0.017	1
11/15/96 10:33:49 AM	A	6.383	0.801	0.100	6
12/6/96 10:54:00 AM	C	6.697	0.841	0.017	1
12/6/96 12:32:55 PM	A	3.152	0.396	0.100	6
12/7/96 11:39:42 PM	C	5.393	0.677	0.017	1
12/24/96 10:02:20 PM	C	7.115	0.893	0.383	23
12/24/96 10:14:22 PM	A	7.125	0.894	0.383	23

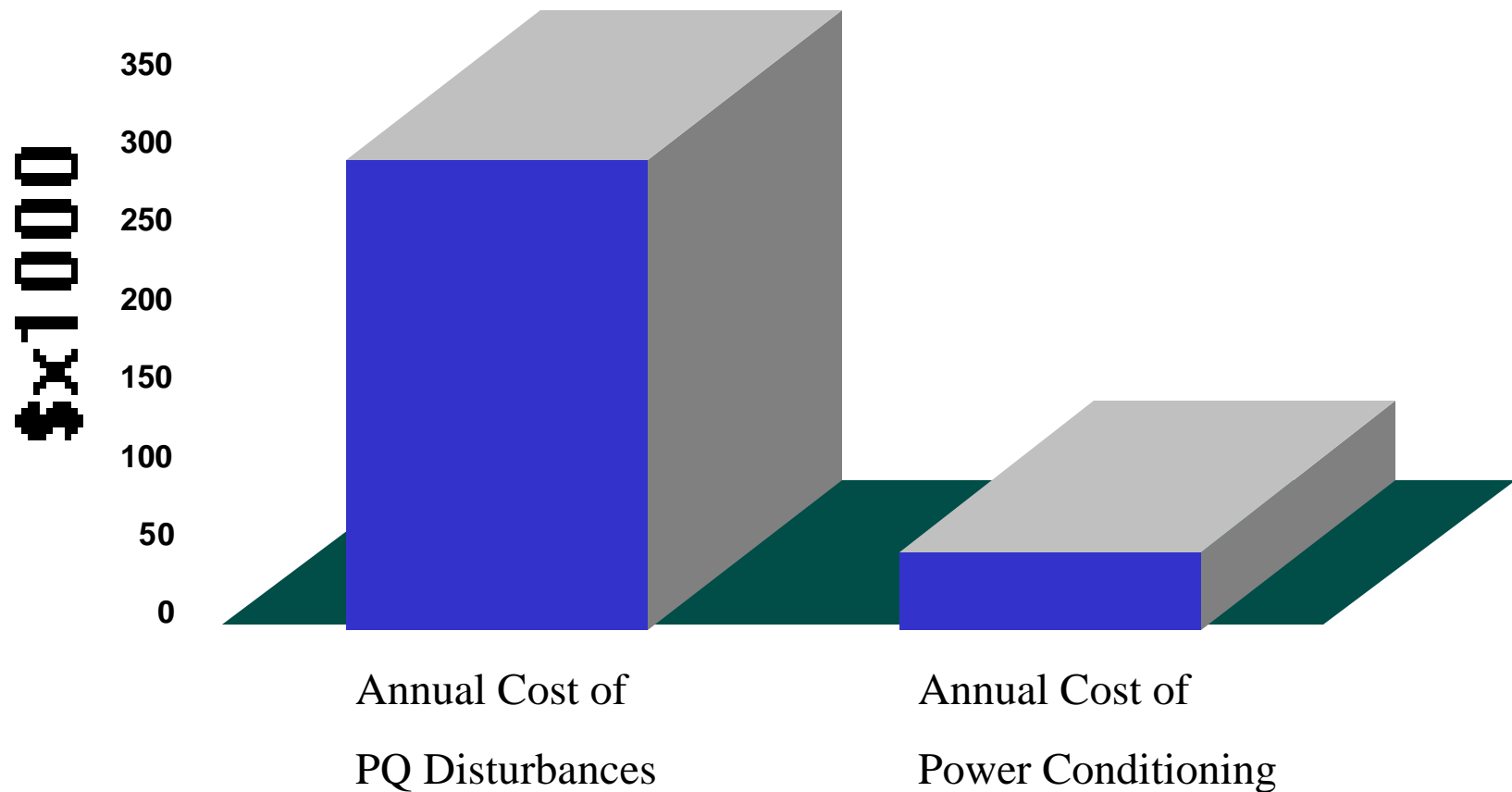
Distribution of Events



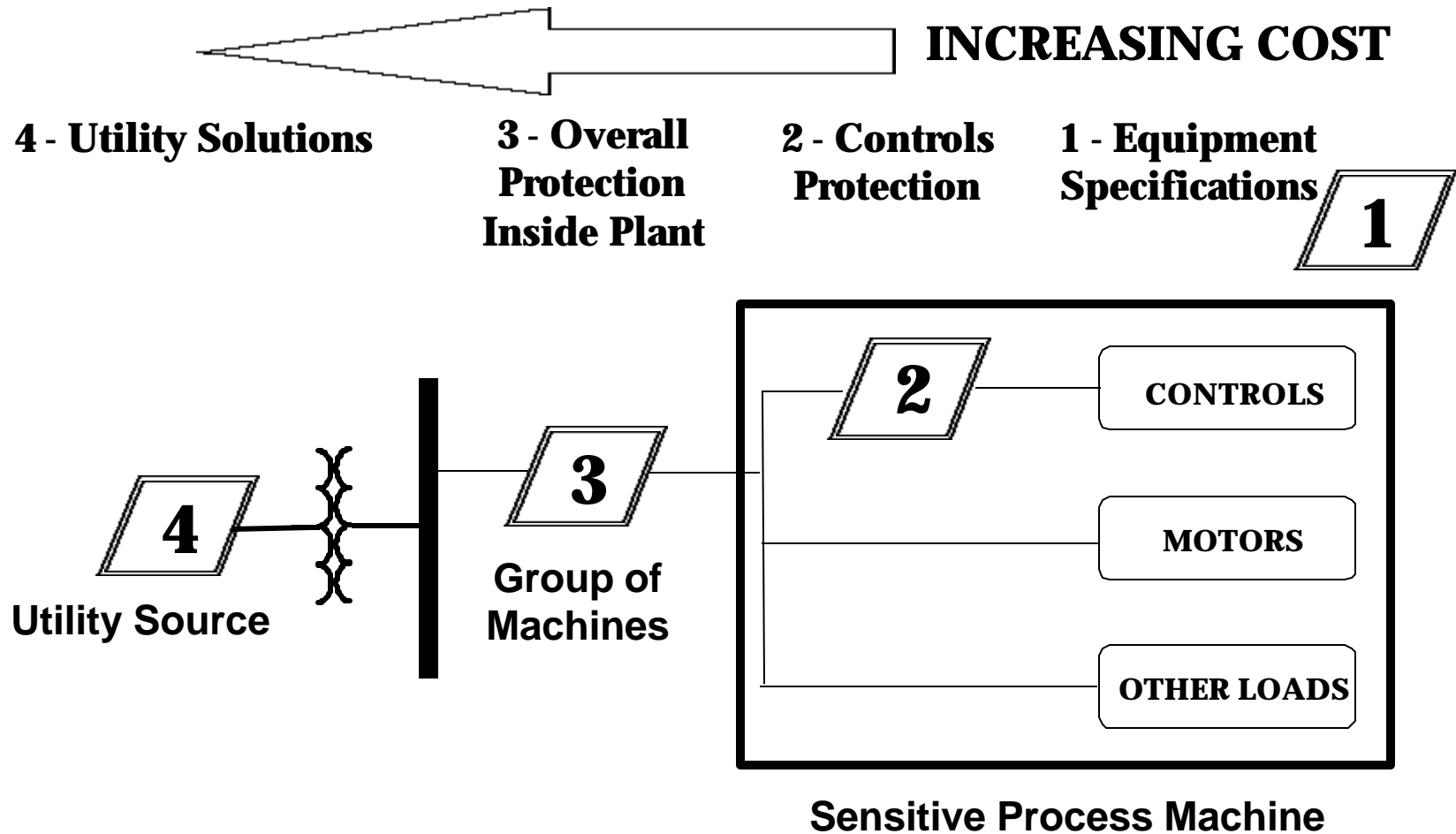
Annual Disturbance Profile

Category of Disturbance	Data	Minimum Voltage				
		<10%	10%-50%	50%-70%	70%-90%	<90%
Interruptions (Feeder or Substation)	Substation Data	0.0				
	480V Bus	0.0				
	Data used in economic analysis	0.1				
1- or 2-Phase Sags due to Faults on Parallel Feeders	Substation Data	0.0	2.645	0.000	7.935	10.58
	480V Bus	0.0	1.323	1.323	6.613	9.258
	Data used in economic analysis	0	1.5	1.5	8.0	9.0
3-Phase Sags due to Faults on Parallel Feeders	Substation Data	0.0	0.000	0.000	0.000	0.000
	P 480V Bus	0.0	0.000	0.000	0.000	0.000
	Data used in economic analysis	0	0	0	0	0
1- or 2-Phase Sags due to Faults on the Transmission System	Substation Data	0.0	2.645	2.645	13.225	18.515
	480V Bus	0.0	0.000	3.968	1.323	5.290
	Data used in economic analysis	0	0	4	1.5	5.5
3-Phase Sags due to Faults on Transmission System	Substation Data	0.0	0.000	0.000	3.968	3.968
	480V Bus	0.0	0.000	1.323	15.870	17.193
	Data used in economic analysis	0	0	1.5	16	17

Cost Benefit Analysis



Voltage Sags - What is Economical?

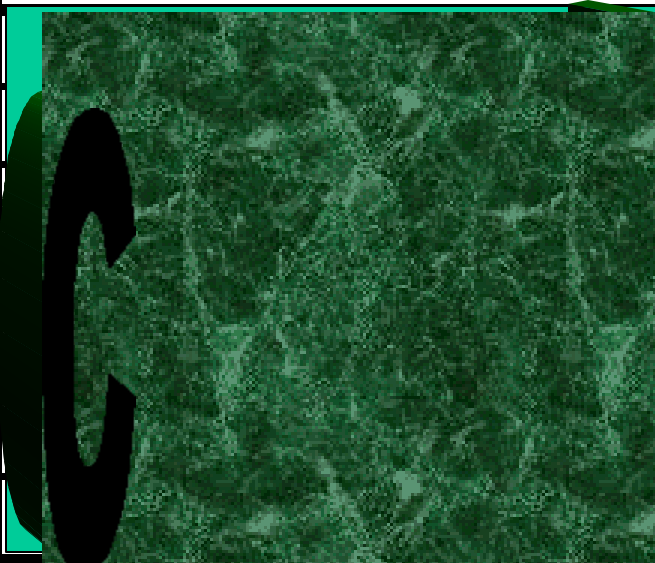


Evaluate Alternative Solutions

- Low cost solutions (protecting equipment controls, equipment modifications)
- Magnetic synthesizers
- UPS and other energy storage technologies
- Synchronous machine/diesel generator systems

Evaluate expected percentage of events that can be solved with each type of solution.

Costs of Various Solutions

Device	Price/kVA*
UPS	
CVT	
SMES	
Conventional M-G Set	
Written Pole M-G Set	
Magnetic Synthesizer	
STS**	

* Does not include operating cost

** Does not include cost of additional feeder

Baseline Annual Cost of Disturbances

Event	Cost Factor	Events/Yr	Cost/Yr
Interruption due to fault at Sub	1	0.1	\$ 10,000
<50% Sag impacting 1 or 2 phases from distribution lines	0.9	1.5	\$ 135,000
50-70% Sag impacting 1 or 2 phases from distribution lines	0.6	1.5	\$ 90,000
70-90% Sag impacting 1 or 2 phases from distribution lines	0.2	8	\$ 160,000
<50% Sag impacting 3 phases from distribution lines	0.9	0	\$ -
50-70% Sag impacting 3 phases from distribution lines	0.6	0	\$ -
70-90% Sag impacting 3 phases from distribution lines	0.2	0	\$ -
<50% Sag impacting 1 or 2 phases from transmission system	0.9	0	\$ -
50-70% Sag impacting 1 or 2 phases from transmission system	0.6	4	\$ 240,000
70-90% Sag impacting 1 or 2 phases from transmission system	0.2	1.5	\$ 30,000
<50% Sag impacting 3 phases from transmission system	0.9	0	\$ -
50-70% Sag impacting 3 phases from transmission system	0.6	1.5	\$ 90,000
70-90% Sag impacting 3 phases from transmission system	0.2	16	\$ 320,000
Total		34	\$ 1,065,000



One Alternative

Event	Cost Factor	Events/Yr	Base Cost/Yr	Expected Reduction	Remaining Cost/Yr
Interruption due to fault at Sub Sub	1	0.1	\$ 10,000	0	\$ 10,000
<50% Sag impacting 1 or 2 phases from distribution lines	0.9	1.5	\$ 135,000	50	\$ 67,500
50-70% Sag impacting 1 or 2 phases from distribution lines	0.6	1.5	\$ 90,000	100	\$ -
70-90% Sag impacting 1 or 2 phases from distribution lines	0.2	8	\$ 160,000	100	\$ -
<50% Sag impacting 3 phases from distribution lines	0.9	0	\$ -	0	\$ -
50-70% Sag impacting 3 phases from distribution lines	0.6	0	\$ -	50	\$ -
70-90% Sag impacting 3 phases from distribution lines	0.2	0	\$ -	100	\$ -
<50% Sag impacting 1 or 2 phases from transmission system	0.9	0	\$ -	50	\$ -
50-70% Sag impacting 1 or 2 phases from transmission	0.6	4	\$ 240,000	50	\$ 120,000
70-90% Sag impacting 1 or 2 phases from transmission	0.2	1.5	\$ 30,000	100	\$ -
<50% Sag impacting 3 phases from transmission system	0.9	0	\$ -	0	\$ -
50-70% Sag impacting 3 phases from transmission	0.6	1.5	\$ 90,000	50	\$ 45,000
70-90% Sag impacting 3 phases from transmission	0.2	16	\$ 320,000	100	\$ -
Total		34	\$ 1,065,000		\$ 242,500
				Benefit	\$ 822,500

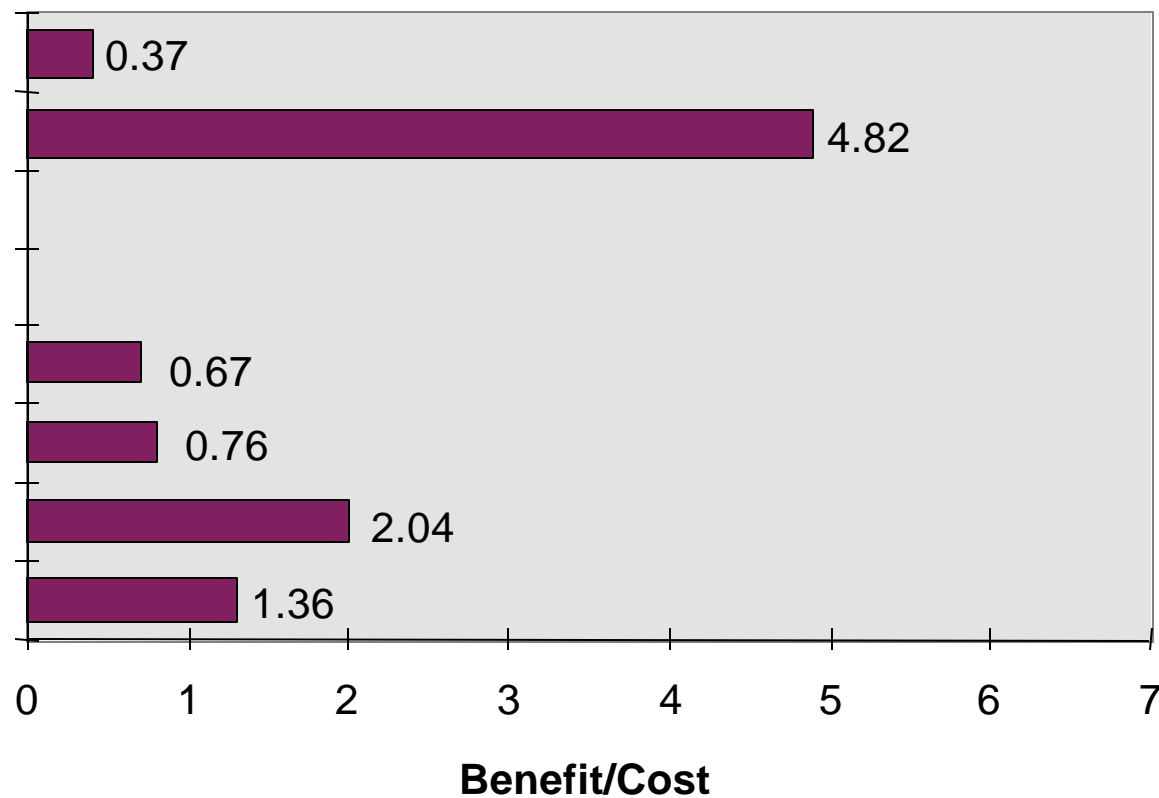
Another Alternative

Event	Cost Factor	Events/Yr	Base Cost/Yr	Expected Reduction	Remaining Cost/Yr
Interruption due to fault at North Haven	1	0.1	\$ 10,000	0	\$ 10,000
<50% Sag impacting 1 or 2 phases from distribution lines	0.9	1.5	\$ 135,000	20	\$ 108,000
50-70% Sag impacting 1 or 2 phases from distribution lines	0.6	1.5	\$ 90,000	40	\$ 54,000
70-90% Sag impacting 1 or 2 phases from distribution lines	0.2	8	\$ 160,000	40	\$ 96,000
<50% Sag impacting 3 phases from distribution lines	0.9	0	\$ -	20	\$ -
50-70% Sag impacting 3 phases from distribution lines	0.6	0	\$ -	40	\$ -
70-90% Sag impacting 3 phases from distribution lines	0.2	0	\$ -	40	\$ -
<50% Sag impacting 1 or 2 phases from transmission system	0.9	0	\$ -	20	\$ -
50-70% Sag impacting 1 or 2 phases from transmission	0.6	4	\$ 240,000	40	\$ 144,000
70-90% Sag impacting 1 or 2 phases from transmission	0.2	1.5	\$ 30,000	40	\$ 18,000
<50% Sag impacting 3 phases from transmission system	0.9	0	\$ -	20	\$ -
50-70% Sag impacting 3 phases from transmission	0.6	1.5	\$ 90,000	40	\$ 54,000
70-90% Sag impacting 3 phases from transmission	0.2	16	\$ 320,000	40	\$ 192,000
Total		34	\$ 1,065,000		\$ 676,000
				Benefit	\$ 389,000

Comparison of Alternatives

Power Conditioning Technology	Cost Benefit	Capital Cost	Operating Cost	Annual Cost	Benefit/Cost Ratio
Utility Side Options					
	\$ 375,000	\$ 1,000,000	2%	\$ 275,375	1.36
	\$ 375,000	\$ 600,000	5%	\$ 183,823	2.04
	\$ 822,500	\$ 3,000,000	10%	\$1,082,226	0.76
	\$ 720,000	\$ 3,000,000	10%	\$1,074,627	0.67
Customer Side Options					
	\$ 389,000	\$ 200,000	15%	\$ 80,705	4.82
	\$ 903,750	\$ 6,000,000	15%	\$2,442,568	0.37

Benefit/Cost Ratios of Various Power Protection Strategies



Economic Considerations

Costs of Power Quality Problems	Costs of Power Conditioning Solutions
<ul style="list-style-type: none">• Lost production due to downtime• Product quality impacts• Equipment damage and/or failure• Additional labor costs• Product reworks• Impacts on customer relations (e.g., late delivery, lost sales)• Cost of investigations into problem• Impacts on energy use and efficiency (e.g., harmonic heating)	<ul style="list-style-type: none">• Evaluation, design, and planning• Initial capital costs• Installation• Costs of space and auxiliary equipment such as air conditioning• Environmental impacts• Operating costs, including efficiency impacts• Maintenance• Regular equipment replacement requirements (e.g., batteries)