

The Economics of Custom Power

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PQ Problems have Costs



\$50 billion per year in the USA is lost as a result of power quality breakdown.

SOURCE: Bank of America Report

A manufacturing company lost more than \$3 million one day last summer in Silicon Valley when the “lights went out.”

SOURCE: New York Times, January, 2000

“A voltage sag in a paper mill can waste a whole day of production — \$250,000 loss.”

SOURCE: Busines Week, June 17, 1996

Half of all computer problems and one-third of all data loss can be traced back to the power line.

SOURCE: Contingency Planning Research, LAN Times

Factors affecting PQ Costs

- Lost production
- Scrap
- Costs to restart
- Labor costs
- Equipment damage and repair
- Other costs

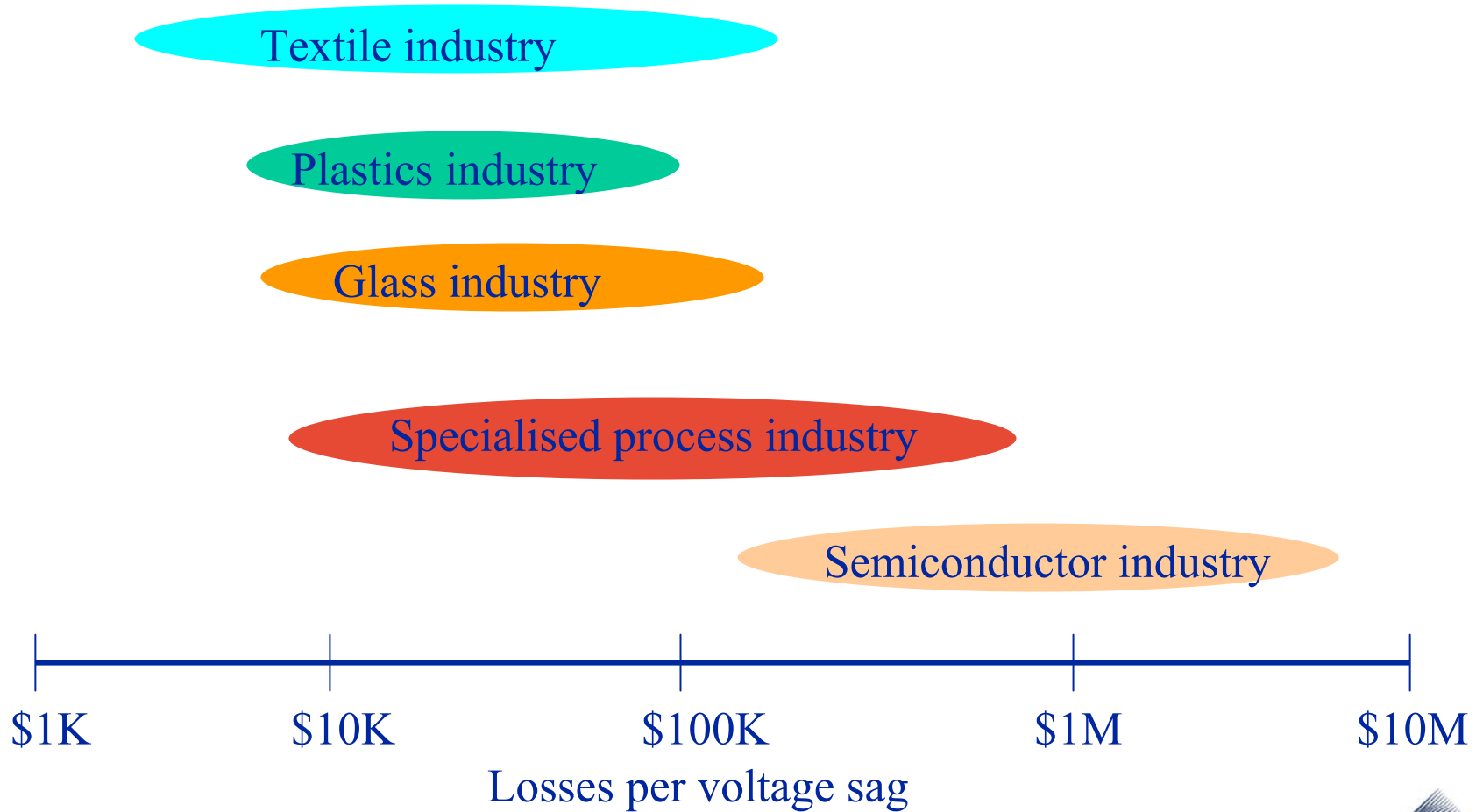


Categories of Interruption Costs

- High cost facilities
 - Semiconductor plants
 - Pharmaceuticals
 - Data centers
- Medium Cost Facilities
 - Automotive manufacturing
 - Glass Plants
 - Plastics and chemicals
 - Textiles



Example costs

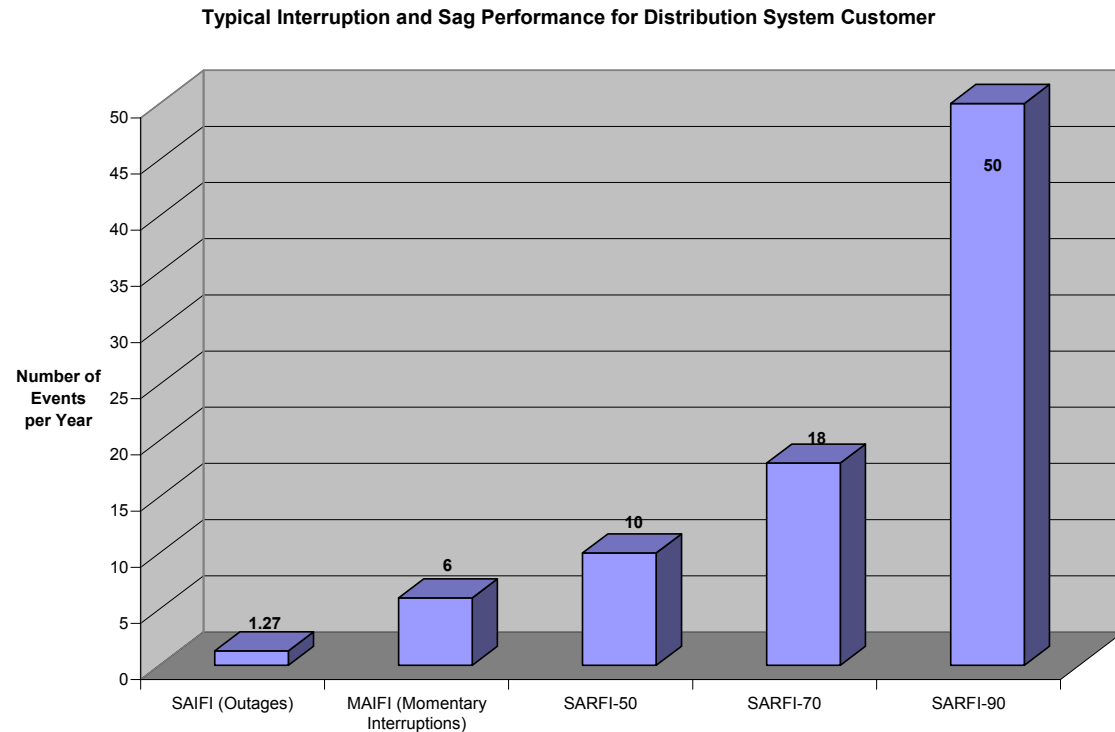


Costs of Momentary Interruptions

Category	Cost of Momentary Interruption (\$/kW Demand)	
	Minimum	Maximum
INDUSTRIAL		
Automobile Manufacturing	\$5.0	\$7.5
Rubber and Plastics	\$3.0	\$4.5
Textile	\$2.0	\$4.0
Paper	\$1.5	\$2.5
Printing (newspapers)	\$1.0	\$2.0
Petrochemical	\$3.0	\$5.0
Metal Fabrication	\$2.0	\$4.0
Glass	\$4.0	\$6.0
Mining	\$2.0	\$4.0
Food Processing	\$3.0	\$5.0
Pharmaceutical	\$5.0	\$50.0
Electronics	\$8.0	\$12.0
Semiconductor Manufacturing	\$20.0	\$60.0
COMMERCIAL		
Communications, information processing	\$1.0	\$10.0
Hospitals, banks, civil services	\$2.0	\$3.0
Restaurants, bars, hotels	\$0.5	\$1.0
Commercial shops	\$0.1	\$0.5

What about voltage sags?

- Facilities experience many more voltage sags than interruptions



Evaluating the economics

1. Characterize the system power quality performance

Reliability Performance

Voltage Sag Performance

Other Important Power Quality Variations

2. Estimate the costs associated with power quality variations

Costs of complete interruptions

Dependence on duration of interruptions

Sensitivity of process to voltage sags

Impact of other power quality variations

3. Characterize available solutions in terms of cost and effectiveness

What technologies can be used?

Cost of the solution technology

Effectiveness for PQ improvement

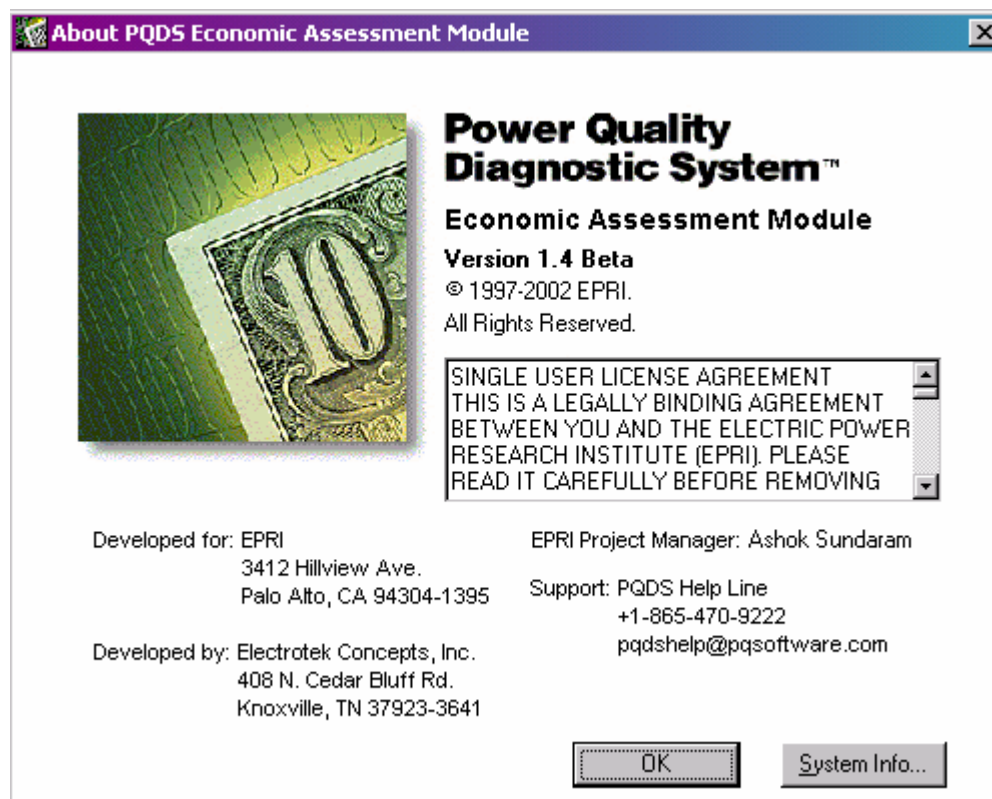
4. Evaluate the economics of the different alternatives

Convert all costs to equiv. annual costs

Compare alternatives

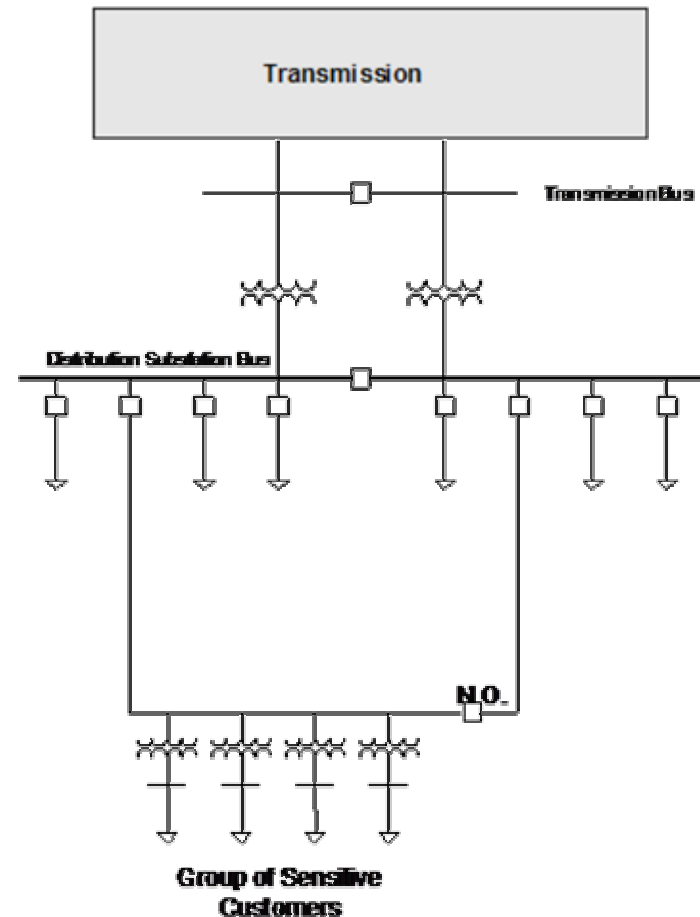
Evaluating the Economics

- Economic Assessment Module (EAM).

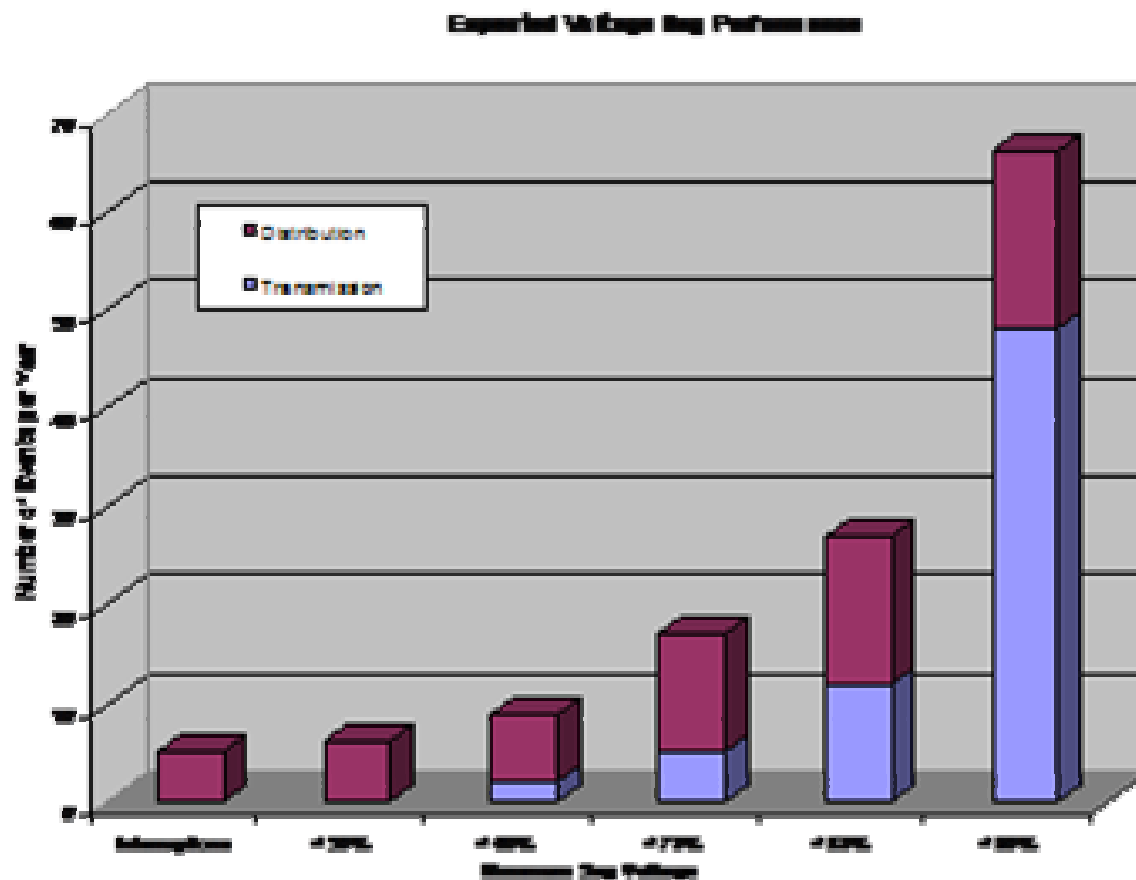


Example System

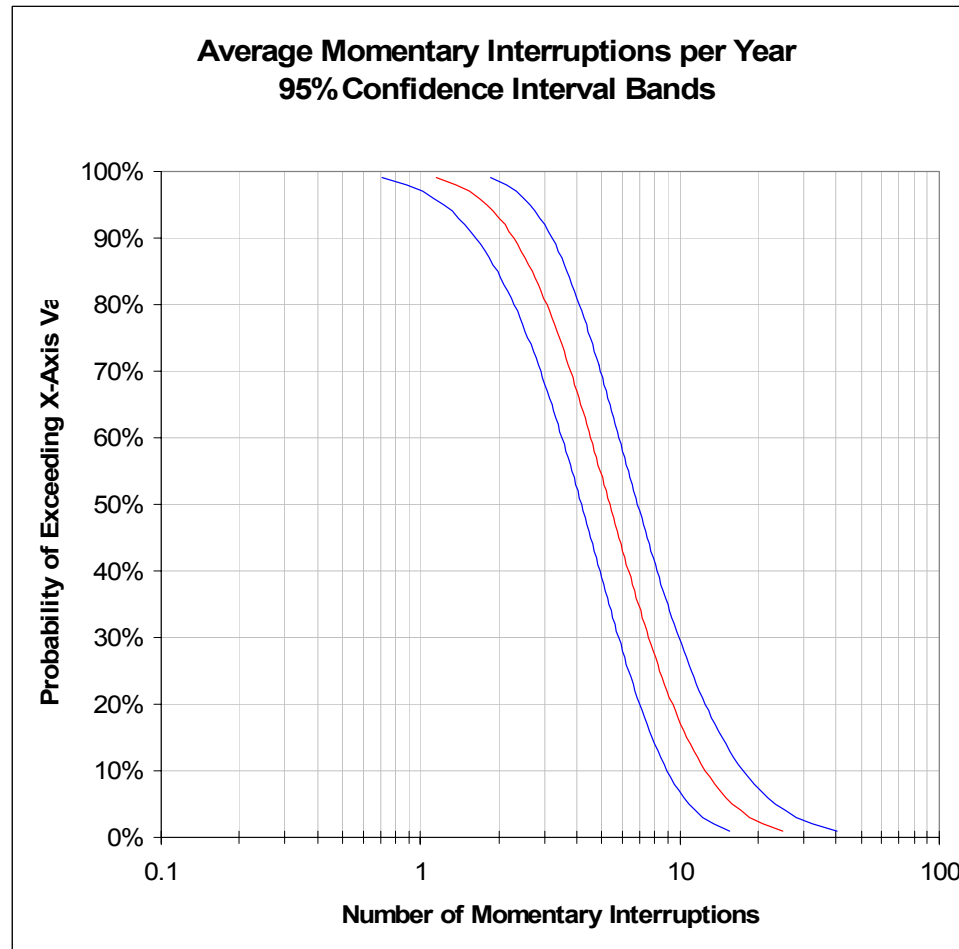
- Economics of improving power quality to a group of customers
- Focus on voltage sags because this is typically the most important (costly) PQ variation



Characterizing System Performance



Remember that the performance is not deterministic – it VARIES



EAM

Characterize PQ Levels

PQDS Economic Assessment Module - sample2.mdb - [Characterize PQ]

File Edit View Steps Setup Reports Help

Characterize PQ

Steps Setup

Define System

Characterize PQ

Determine Costs

Select Improvement

Evaluate

ManufacturerS

Substation S

Feeder To S

ManufacturerS

PF CF TS Other

Parallel Feeder

Voltage Sags and Interruptions (Events/Month)

Voltage Range ->	80-90%	70-80%	50-70%	10-50%	0-10%
1 or 2 Phase Instantaneous	1	1	1	0.5	0
1 or 2 Phase Momentary	0	0	0	0	0
1 or 2 Phase Temporary	0	0	0	0	0
3 Phase Instantaneous	0.5	0.5	0.5	0.5	0
3 Phase Momentary	0	0	0	0	0
3 Phase Temporary	0	0	0	0	0

Characterizing costs – concept of Weighting Factors

Category of Event	Weighting for Economic Analysis	Expected Number per Year	Equivalent Interruptions per Year
Interruption	100%	5	5.0
Sag below 50%	100%	1	1.0
Sag between 50% and 70%	70%	13	9.1
Sag between 70% and 80%	40%	10	4.0
Sag between 80% and 90%	10%	39	3.9
TOTAL		68	23.0

EAM

Determine costs of pq problems

PQDS Economic Assessment Module - sample2.mdb - [Determine Costs]

File Edit View Steps Setup Reports Help

Define System
Characterize PQ
Determine Costs
Select Improvement
Evaluate

Determine Costs

ManufacturerS

Substation S
 Feeder To S
 ManufacturerS

Ext. Outage
Cost / Event

Miscellaneous
Weight Factors

Utility Cost
Other PQ Costs

Weighting Factors

Voltage Range ->	80-90%	70-80%	50-70%	10-50%	0-10%
1 or 2 Phase Instantaneous	0.1	0.1	0.4	0.8	1
1 or 2 Phase Momentary	1	1	1	1	1
1 or 2 Phase Temporary	1	1	1	1	1
3 Phase Instantaneous	0.1	0.1	0.4	0.8	1
3 Phase Momentary	1	1	1	1	1
3 Phase Temporary	1	1	1	1	1

Develop Solution Options

- Equipment Protection
 - CVT
 - Local DVR technologies
 - UPS
- Facility Service Entrance Protection
 - DVR
 - Standby Power Supply (batteries, flywheels, superconducting magnets, supercapacitors)
- Custom Power Options on Supply System
 - DVR
 - Static Switch or Fast Transfer Switch
 - Combination



EAM

Costs of Solution Options

PQDS Economic Assessment Module - sample2.mdb - [Select Improvement]

File Edit View Steps Setup Reports Help

Steps Setup

Define System

Characterize PQ

Determine Costs

Select Improvement

Evaluate

Select Improvement

Base Case:

Base Case

Case

SSD or AC Battery

Name
SSD or AC Battery

Comments

PQ Solutions

System	Sags Avoided	Other Avoided
Feeder	Feeder To S	
Customer	ManufacturerS	
Process		
Solution	SSD or AC Battery1	
Customer Cost	100	%
Size	2000	kVA
Purchase (\$/kVA)	800	
Installation (\$)	0	
O and M (\$/yr)	240000	
Comments	Full kVA rating not required	

Record 1 of 1

PQ Solution to Import into New Record:
Feeder Reactors1

Performance of the Solution Options

Type of Condition Affecting Customer	Weighting	Base Performance (events/year)	Reduction with Controls Protection	Reduction with Service Entrance Energy Storage	Reduction with Primary Static Switch	Reduction with DVR
Interruptions	1	50	0%	80%	100%	0%
Sags below 50%	1	10	0%	100%	100%	20%
Sags 50-70%	0.7	130	30%	90%	87%	100%
Sags 70-80%	0.4	100	60%	95%	30%	100%
Sags 80-90%	0.1	300	90%	95%	8%	100%
TOTAL EVENTS AFFECTING PLANT		610	230	48	447	58
Total Events Weighted for Severity		230	144	23	7.6	58

EAM Performance of solution

PQDS Economic Assessment Module - sample2.mdb - [Select Improvement]

File Edit View Steps Setup Reports Help

Define System
Characterize PQ
Determine Costs
Select Improvement
Evaluate

Select Improvement

Base Case:
Base Case

Case

SSD or AC Battery

Name
SSD or AC Battery

Comments

PQ Solutions

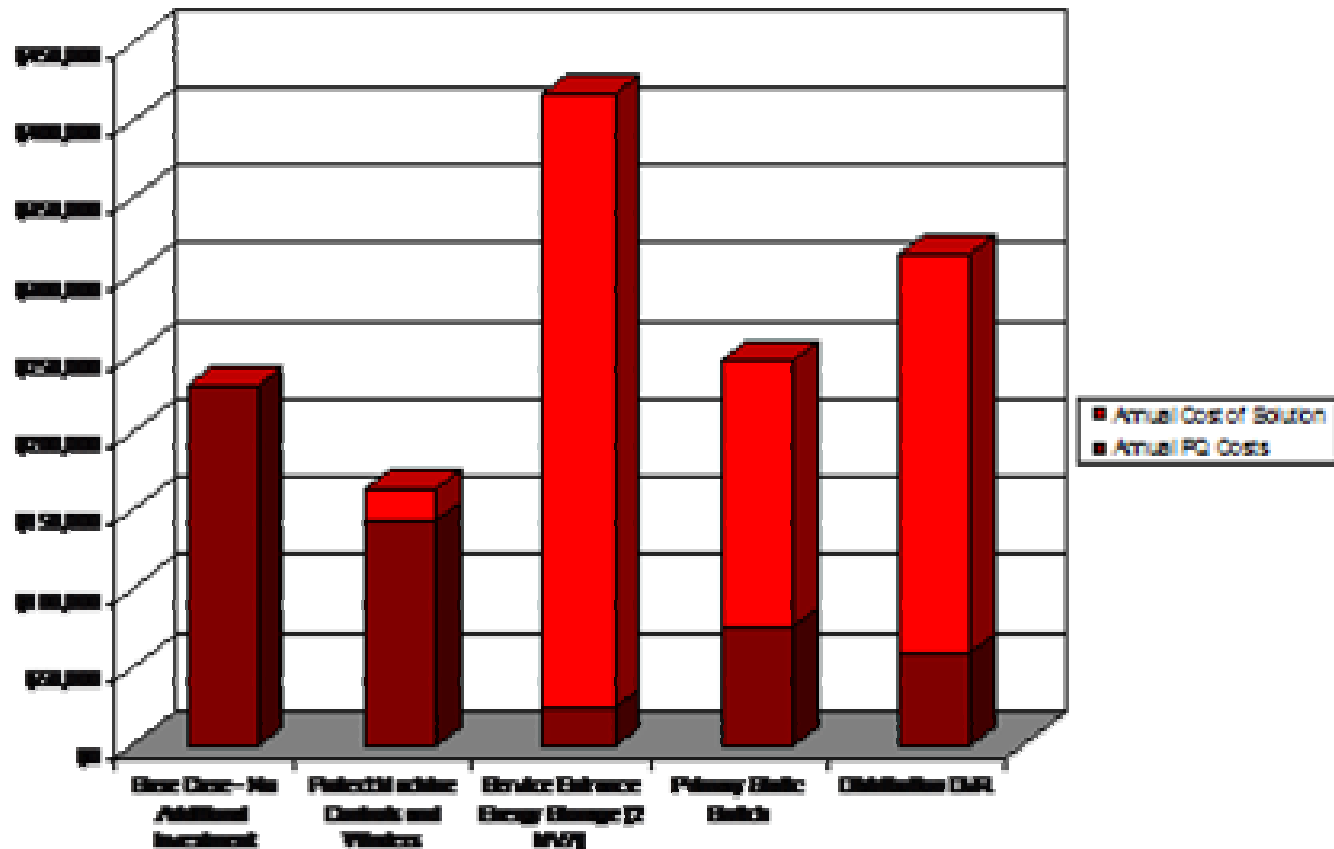
System	Sags Avoided	Other Avoided									
		% Avoided									
		PF			CF			TS			
Phases	Percent	Ins	Mom	Tem	Ins	Mom	Tem	Ins	Mom	Tem	
1 or 2	80 to 90	100	0	0	0	0	0	0	100	0	0
1 or 2	70 to 80	100	0	0	0	0	0	0	100	0	0
1 or 2	50 to 70	100	0	0	0	0	0	0	100	0	0
1 or 2	10 to 50	100	0	0	0	0	0	0	100	0	0
1 or 2	< 10	100	0	0	0	0	0	0	100	0	0
3	80 to 90	100	0	0	0	0	0	0	100	0	0
3	70 to 80	100	0	0	0	0	0	0	100	0	0
3	50 to 70	100	0	0	0	0	0	0	100	0	0
3	10 to 50	100	0	0	0	0	0	0	100	0	0
3	< 10	100	0	0	50	0	0	0	100	0	0

Record 1 of 1

PQ Solution to Import into New Record:
Feeder Reactors1

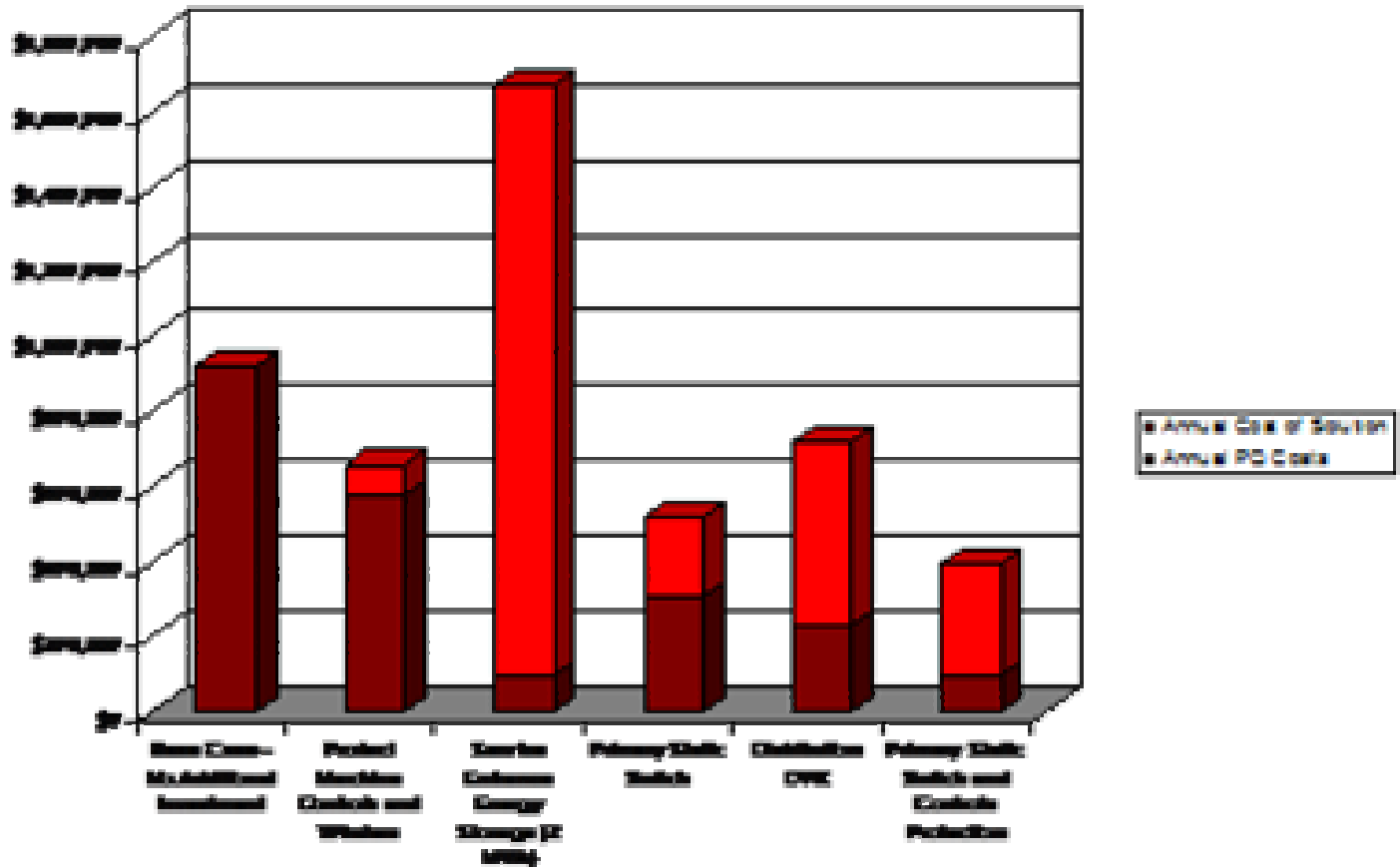
Cost Comparison for a Single Customer

Options for Performance Improvement - Initial and Final Evaluation



Cost Comparison for Multiple Customers

Options for Performance Improvement - 4 plants, one plant



Economic evaluation - Summary

- Convert everything to equivalent annual costs
- Calculate a base cost using existing conditions
- Look at the reduction in costs associated with each alternative
- Find the minimum TOTAL costs