# How To Justify Equipment Improvements Using Life Cycle Costs & Reliability Principles

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# Definitions

- **Reliability**--The probability that a component, device, system, or process will perform its intended function without failure for a given time when operated correctly in a specified environment
- **Life Cycle Costs**--All costs associated with the acquisition and ownership of a system over its full life. The usual figure of merit is net present value. The lowest long term cost of ownership is a frequent goal.
- **Net Present Value**-- NPV is a financial tool for evaluating economic value added. The present value of an investment's future net cash flows minus the initial investment for a given hurdle discount rate are summed for the net.

 

# Similarities: Safety & Reliability

Safety

- Safety policies plan for zero accidents
- Safety issues involve human learning
- Safety involves altruism and money

Reliability

- Reliability issues plan for zero failures
- Reliability issues involve entropy deterioration often caused by aging effects
- Reliability involves money and alternatives

Alternatives is a plural word!!

 

# Reliability vs Maintenance

- **Reliability-**
  - Long range strategic approach
  - **Dedicated to forecasting and avoiding failures**
- **Maintenance-**
  - Short range adrenaline driven tactical approach
  - Dedicated to restoring equipment quickly
- **Both areas have similarities and interests. Each relies on the other**

 

## Why Work On LCC

- **Affordability studies**
- **Source selection studies**
- **Design trade-off studies**
- **Repair level analysis studies**
- **Warranty and repair cost studies**
- **Supplier sales strategies**
- **Configure for lowest long term cost of ownership**
- **Sales aids for the Rainmakers**

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## Rainmakers

- **Rainmakers have magic for American Indians**
  – No rain, no crops, no life
- **Rainmakers are important sales people:**
  – **No orders, no revenue, no business, no future**
- **Rain is the customers money**
- **Rainmakers are your few ace sales people**
- **Rainmakers are not born. They are made. Life cycle cost can be a powerful tool for $'s**

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## Rainmakers Credo*

- Cherish customers—treat them as best friends
- Listen to customers—make/provide what they want
- Monetize product values—show customers the value of what they get from your product
- Make your product the way customers want it and deliver it to match their needs
- Remind customers of the monetized value received
- Give customers more than expected and help them pay without embarrassment—ask to do it again

*** How To Become A Rainmaker,**
Jeffrey J. Fox, Hyperion Press, NY, 2000
ISBN 0-7868-6595-4




## Monetize Details For Rainmakers

- Describe in money the product value to the customer
- Price is the universal comparator for two products
- Focusing only on price is myopic if the true goal is the lowest long term cost of ownership (a LCC statement)
- Engineers must price-out the value for benefits—better, faster, lighter, more reliability must be quantified in monetary terms—not just in golly, gee whiz things!
- The three most important words for rainmakers: money, money, money—explained in customer terms!
- Use reliability tools to get to the money!

## Why Work On Reliability Issues?

- Solving reliability problems solves cost problems
- Solving reliability problems requires new tools to both predict and solve root causes of failures to solve costly old unresolved problems
- Most reliability issues require models, based on actual data, to forecast future performance and predict failures that drive the money issues
- Make reliability improvements pay their way by working toward the lowest life cycle cost
- Reliability tools predict when failures will occur which permit use of life cycle cost techniques

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## Why Is Reliability a Business Issue?

- Equipment failures cost money for repairs
- System failures stop cash inflows plus incur repair costs
- Business needs equipment and processes that are
  - **available** ← ready for duty when needed
  - **reliable** ← free of system failures
  - **maintenance** ← few maintenance interventions
  - **affordable** ← lowest long term cost of ownership
- We speak of technology and reliability but the main issue is money--which infers life cycle costs based on knowing when failures occur!

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# RAM Models

- Reliability and maintainability answer the questions about:
  - **R**eliability
  - **A**vailability
  - **M**aintenance

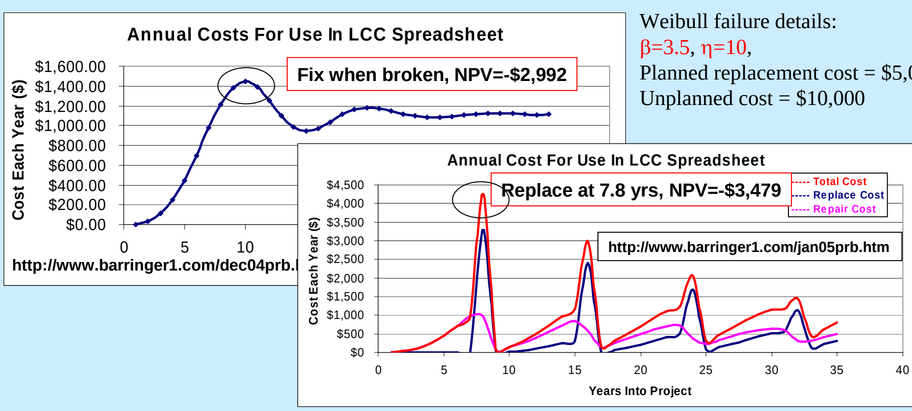
  Software sources for no-cost tool:
  www.barringer1.com/raptor.htm
- RAM models outputs drive operational costs which is connected to acquisition costs

# Maintenance Strategies

- Fix when broken? Timed replacements?

Weibull failure details:
β=3.5, η=10,
Planned replacement cost = $5,000
Unplanned cost = $10,000

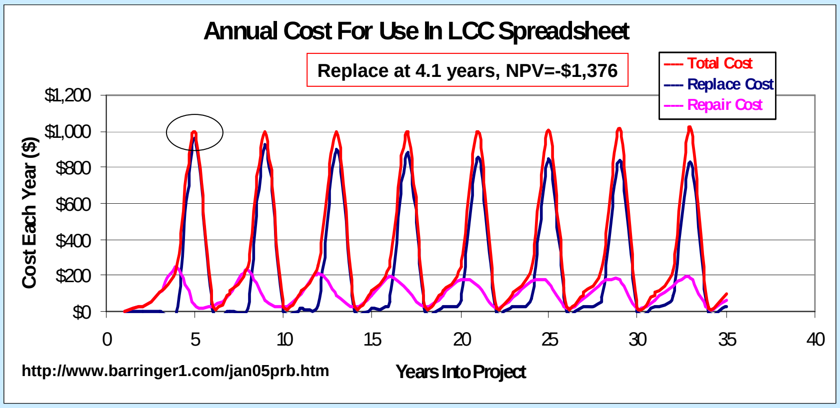


# More Maintenance Strategies

- Different costs structure

Weibull failure details:
β=3.5, η=10,
Planned replacement cost = $1,000
Unplanned cost = $10,000

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# The Problem To Address

- We have two pumps of equal size in parallel. Years ago we operated them as 1 out of 2.
- With de-bottlenecking, we now need 2 out of 2.
- One pump is correctly installed with long life. Other pump is poorly installed with shorter life. Typical maintenance costs are $10,000/failure
- The application is high temp--space is cramped
- Need IRR > 50% with discount rate = 12%

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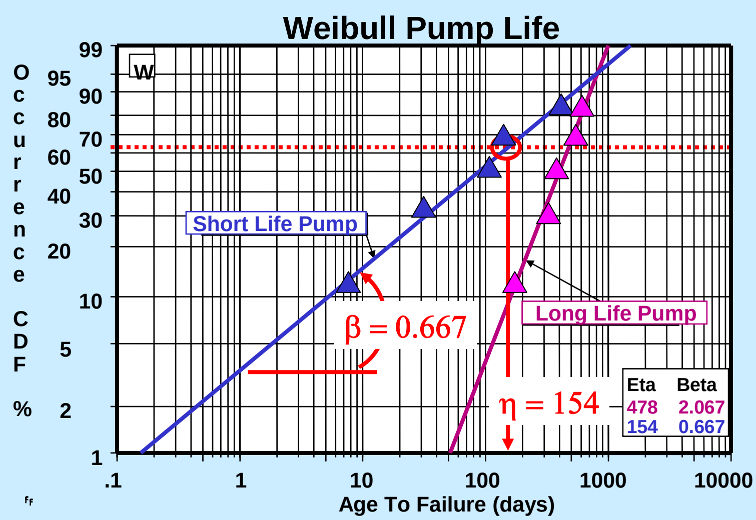
# The Problem To Address-contd

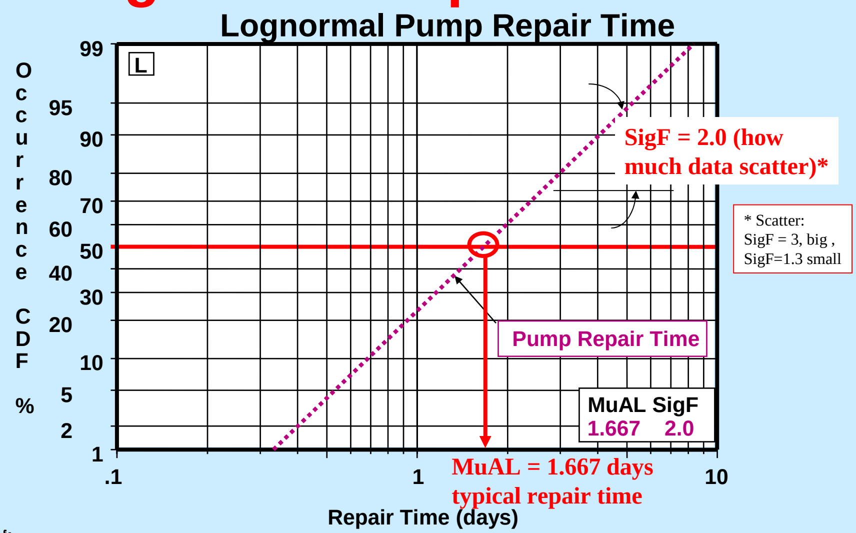
- Long life pump has a Weibull characteristics: beta = 2.067, eta = 478 days
- Short life pump has a Weibull characteristics: beta = 0.667, eta = 174 days
- Repair time is lognormal with 1.6667 days of downtime and standard deviation is 2.0
- Cutback losses are $3,000/hr when 1 out of 2 survive or $10,000/hr when 0 out of 2 survive




# Weibull Plot Of Life



# Lognormal Repair Time






# The Problem To Address-contd

- **Option 1**: **Do nothing**. Live with two old pumps requiring 2 out of 2. Find the costs
- **Option 2**: **Add a big new pump** in parallel with two old pumps. Cost is $75,000. Repair cost is $12,000/failure. No change in repair time and life is same as good pump.
- **Option 3**: **Add a third small pump** for 2 out of 3. Cost is $50,000. Life is like good pump & repair time is same.

# What Reliability Prediction Tools To Use?

**Table 1**

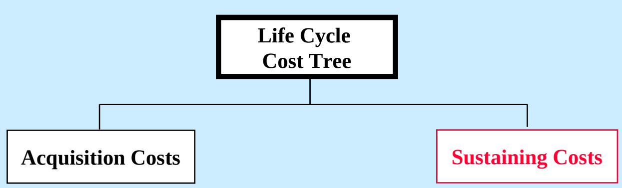
**Short List Of Reliability Engineering Principles Tools**

- ✓ Mean time between failures indices
- TPM and reliability principles
- ✓ Preparing reliability data for analysis
- Decision trees merging reliability and costs
- ✓ Weibull, normal, & log-normal probability plots
- Corrective action for Weibull failure
- ✓ Models & Monte Carlo simulations
- Pareto distributions for vital problems
- Fault tree analysis
- Design review
- Load/strength interactions
- Software reliability tools
- Sudden death and simultaneous testing
- ✓ Failure recording, analysis and corrective action
- Failure mode effect analysis
- Bathtub curves for modes of failure
- Availability, maintainability, capability
- Critical items significantly affecting safety/costs
- Quality function deployment
- Mechanical components testing for interactions
- Electronic device screening and de-rating
- Quality function deployment
- Reliability testing strategies
- Accelerated testing
- Contracting for reliability
- Reliability growth models and displays
- Cost of unreliability
- Reliability policies and specifications
- Reliability audits
- ✓ Management's role in reliability improvements



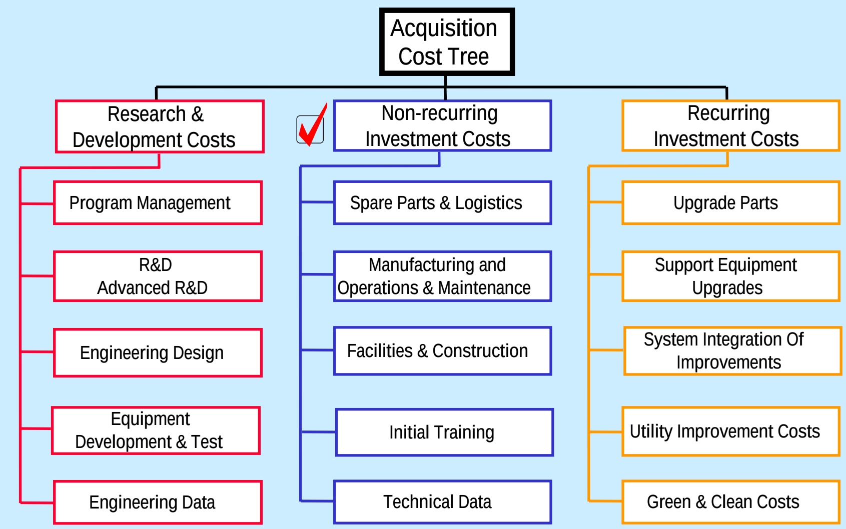
# Life Cycle Cost Elements

- LCC = Acquisition + Sustaining Costs



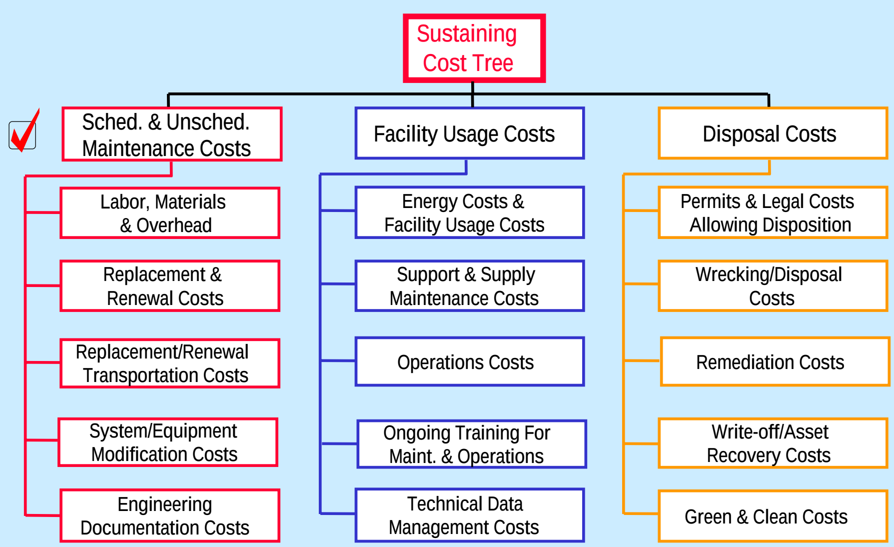

- **Acquisition costs** and **sustaining costs** are **not mutually exclusive**—find both with correct inputs and identifying cost drivers

# Branches For Acquisition Tree



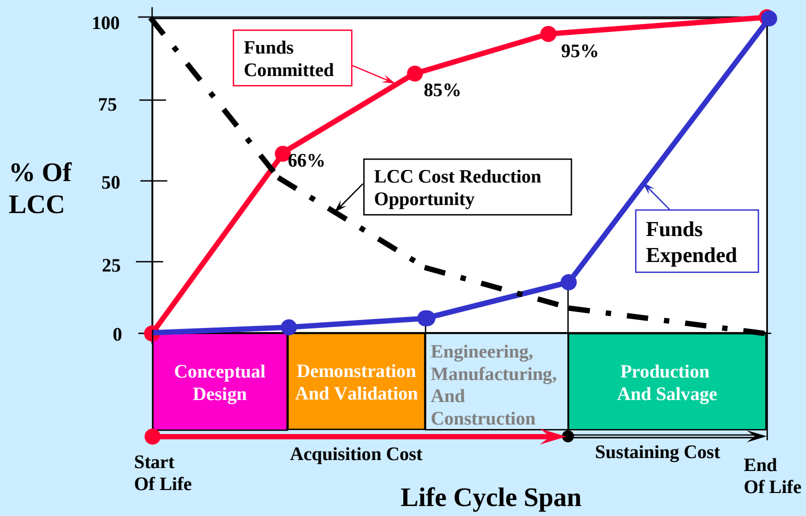

 

# Branches For Sustaining Tree



# Commitments & Expenditures

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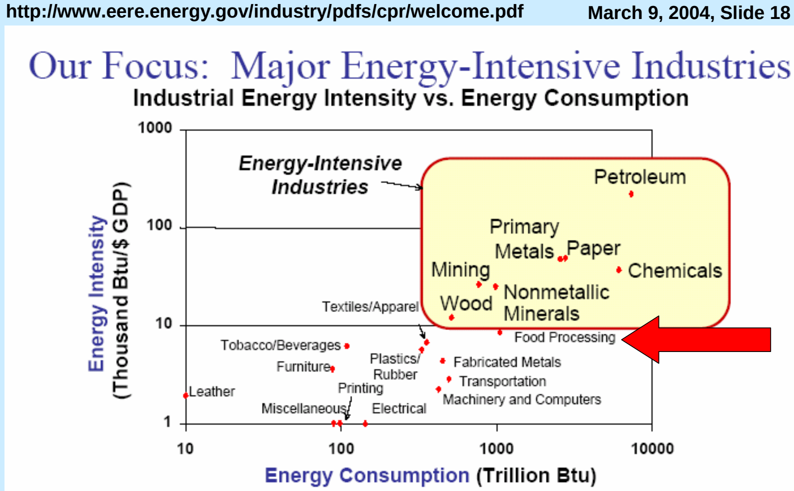
# Don’t Forget Energy Costs

http://www.eere.energy.gov/industry/pdfs/cpr/welcome.pdf March 9, 2004, Slide 18




Sources: EIA 2001, 1998 Manufacturing Energy Consumption Survey; U.S. DOE 2002, Energy and Environmental Profile of the U.S. Mining Industry

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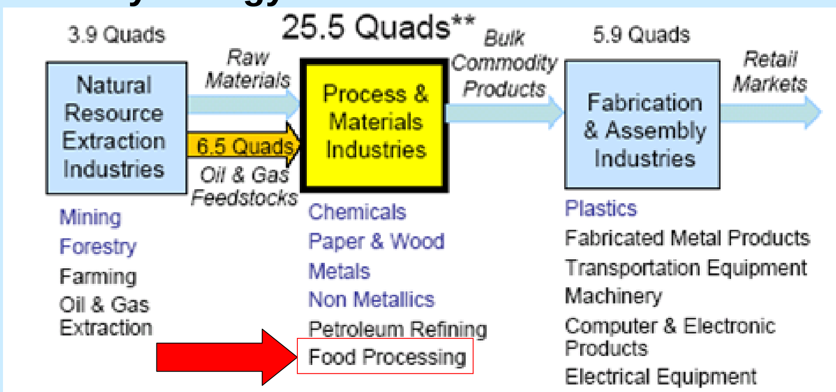
# Food Processing Is In The Energy Consumption/Cost Bullseye!

**http://www.eere.energy.gov/industry/pdfs/cpr/welcome.pdf March 9, 2004, Slide 19**

## Heavy Energy Use in Process Industries*




* 1996 estimates based primarily on MECS and AER data
Includes electricity generation, transmission, and distribution losses
** Includes 6.5 Q oil and gas feedstocks

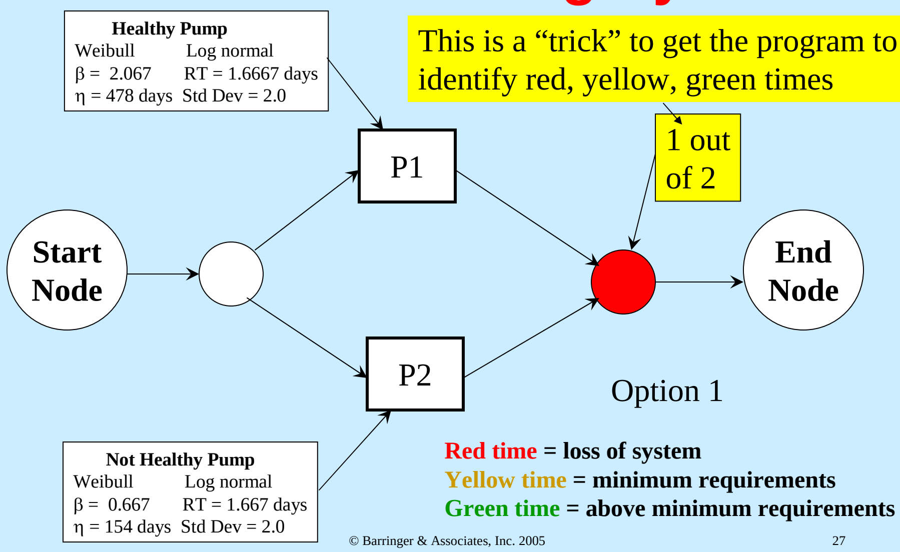
 

# How To Solve The Problem?

- Build a Monte Carlo model using the no-cost PC based RAPTOR model with hyperlinks from **http://www.barringer1.com/raptor.htm**
- RAPTOR is a reliability and maintainability model using reliability block diagrams
- Output from RAPTOR gives time lost and number of repairs each year with data by year so time buckets are correct for LCC spreadsheets

# Model For Existing System



# Model Output--Option 1

**Final Results**

Results from 1000 run(s):

| Parameter | Minimum | Mean | Maximum | Standard Dev |
|---|---|---|---|---|
| Total Costs | 1462.00 | 181818.43 | 1176257.03 | 130780.67 |
| Ao | 0.981704109 | 0.999956007 | 1.0000000000 | 0.000631445 |
| MTBDE | 358.322000 | >724.143943 | >730.000000 | n/a |
| MDT (16 runs) | 0.041639 | 1.003582 | 6.678000 | 1.526086 |
| MTBM | 30.416667 | >225.740270 | >730.000000 | n/a |
| MRT (921 runs) | 0.000000 | 1.599825 | 14.450437 | 1.246611 |
| %Green Time | 91.854515 | 98.834532 | 100.000000 | 1.136733 |
| %Yellow Time | 0.000000 | 1.161069 | 8.145485 | 1.128653 |
| % Red Time | 0.000000 | 0.004399 | 1.829589 | 0.063145 |
| Failures After Reset | 0 | 0.016000 | 1 | 0.125475 |

Total Sim Time=730.000000, Time After Stats Reset=365.000000

Option 1

Note Time Span

# Summary Of Facts-Option 1

**Table 3**

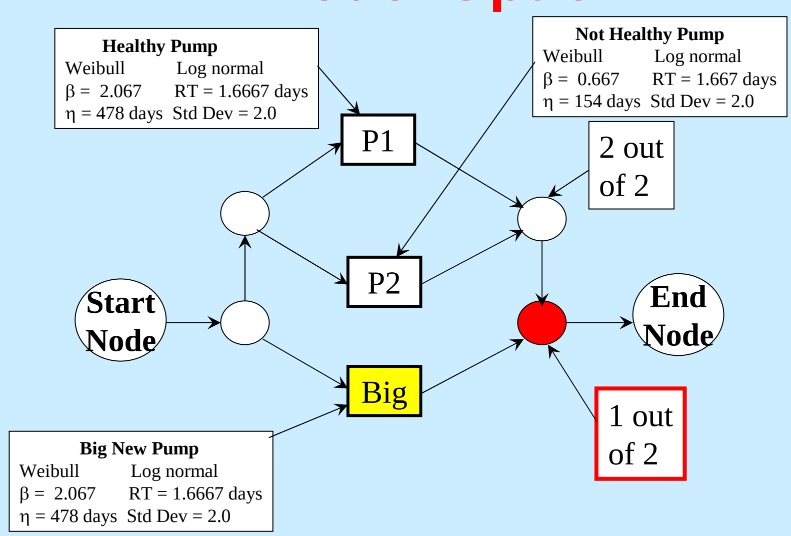
**Datum Case: Do Nothing Alternative--Failure Costs For The Status Quo**

All results based on 1000 trials for each year---statistical data reported for only the year studied.

| Year | Days | Mean Red Time (two pumps down at same time), **(%)** | Mean Red Time Converted To Down Time For Total System Failures, **(hrs/year)** | Mean Number of Red Event System Failures. **(#)** | Mean Red Time For Complete System Failures Converted To Gross Margin Money Lost ($/year) | Mean Yellow Time (Cutback zone-one survives out of two) **(%)** | Mean Yellow Time For Cutbacks Converted To Downtown **(hours/yr)** | Mean Repair Time **(days/ failure)** | Average Number of Cutback Failures Per Year **(#/yr)** | Cutback Conditions Gross Margin Failure Cost Losses **($/yr)** | Gross Margin Losses From Cutbacks and Total System Failures **($/yr)** | Pump Mainte-nance Repair Costs **($/yr)** | Sum Of Gross Margin Losses & Repair Costs **($/yr)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **a** | **b** | **c** | **d** | **e** | **f** | **g** | **h** | **I** | **j** | **k** | **l** | **m** | **n** |
| | | From RAPTOR | 365*(c/100)*24 | From RAPTOR | $10,000*d | From RAPTOR | 365*(g/100)*24 | From RAPTOR | h/(I*24) | $3,000*h | f + k | $10,000*(e + J) | L + N |
| 1 | 365 | 0.002144 | 0.187814 | 0.009 | $1,878 | 1.279285 | 112.0654 | 1.674760 | 2.788095 | $336,196 | $338,074 | $27,971 | $366,045 |
| 2 | 730 | 0.004399 | 0.385352 | 0.016 | $3,854 | 1.161069 | 101.7096 | 1.599825 | 2.648978 | $305,129 | $308,982 | $26,650 | $335,632 |
| 3 | 1095 | 0.002880 | 0.252288 | 0.016 | $2,523 | 1.174653 | 102.8996 | 1.646313 | 2.604294 | $308,699 | $311,222 | $26,203 | $337,425 |
| 4 | 1460 | 0.002312 | 0.202531 | 0.013 | $2,025 | 1.218289 | 106.7221 | 1.638230 | 2.714365 | $320,166 | $322,192 | $27,274 | $349,465 |
| 5 | 1825 | 0.002606 | 0.228286 | 0.012 | $2,283 | 1.167023 | 102.2312 | 1.659235 | 2.567228 | $306,694 | $308,977 | $25,792 | $334,769 |
| 6 | 2190 | 0.001404 | 0.122990 | 0.007 | $1,230 | 1.198115 | 104.9549 | 1.700919 | 2.571034 | $314,865 | $316,095 | $25,780 | $341,875 |
| 7 | 2555 | 0.003302 | 0.289255 | 0.02 | $2,893 | 1.191764 | 104.3985 | 1.654584 | 2.629023 | $313,196 | $316,088 | $26,490 | $342,578 |
| 8 | 2920 | 0.001809 | 0.158468 | 0.014 | $1,585 | 1.173470 | 102.7960 | 1.707165 | 2.508935 | $308,388 | $309,973 | $25,229 | $335,202 |
| 9 | 3285 | 0.002225 | 0.194910 | 0.014 | $1,949 | 1.222295 | 107.0730 | 1.712634 | 2.604980 | $321,219 | $323,168 | $26,190 | $349,358 |
| 10 | 3650 | 0.002040 | 0.178704 | 0.007 | $1,787 | 1.188088 | 104.0765 | 1.659607 | 2.612981 | $312,230 | $314,017 | $26,200 | $340,216 |
| 11 | 4015 | 0.005804 | 0.508430 | 0.021 | $5,084 | 1.197460 | 104.8975 | 1.779037 | 2.456795 | $314,692 | $319,777 | $24,778 | $344,555 |
| 12 | 4380 | 0.001773 | 0.155315 | 0.012 | $1,553 | 1.175174 | 102.9452 | 1.707771 | 2.511686 | $308,836 | $310,389 | $25,237 | $335,626 |
| 13 | 4745 | 0.002105 | 0.184398 | 0.009 | $1,844 | 1.224117 | 107.2326 | 1.649817 | 2.708196 | $321,698 | $323,542 | $27,172 | $350,714 |
| 14 | 5110 | 0.001496 | 0.131050 | 0.009 | $1,310 | 1.196564 | 104.8190 | 1.587960 | 2.750358 | $314,457 | $315,768 | $27,594 | $343,361 |
| 15 | 5475 | 0.002415 | 0.211554 | 0.009 | $2,116 | 1.133094 | 99.2590 | 1.619986 | 2.552981 | $297,777 | $299,893 | $25,620 | $325,512 |
| 16 | 5840 | 0.002512 | 0.220051 | 0.013 | $2,201 | 1.160906 | 101.6954 | 1.601372 | 2.646048 | $305,086 | $307,287 | $26,590 | $333,877 |
| 17 | 6205 | 0.005928 | 0.519293 | 0.01 | $5,193 | 1.167567 | 102.2789 | 1.663234 | 2.562249 | $306,837 | $312,030 | $25,722 | $337,752 |
| 18 | 6570 | 0.003201 | 0.280408 | 0.016 | $2,804 | 1.265275 | 110.8381 | 1.725613 | 2.676297 | $332,514 | $335,318 | $26,923 | $362,241 |
| 19 | 6935 | 0.004091 | 0.358372 | 0.015 | $3,584 | 1.122020 | 98.2890 | 1.567801 | 2.612177 | $294,867 | $298,451 | $26,272 | $324,722 |
| 20 | 7300 | 0.004691 | 0.410932 | 0.015 | $4,109 | 1.254588 | 109.9019 | 1.795161 | 2.550883 | $329,706 | $333,815 | $25,659 | $359,474 |
| | | | **Average =** | **0.013** | **$2,590** | | | | **2.614** | **$313,663** | **$316,253** | **$26,267** | **$342,520** |

# RAM Model Option 2



# Summary Of Facts-Option 2

**Table 4 - Failure Cost Details**

**Alternate #1: Add Large New Pump For $75,000 Capital Addition**

All results based on 1000 trials for each year---statistical data reported for only the year studied.

| Year | Days | Mean Red Time (two pumps down at same time), **(%)** | Mean Red Time Converted To Down Time For Total System Failures, **(hrs/year)** | Mean Number of Red Event System Failures. **(#)** | Mean Red Time For Complete System Failures Converted To Gross Margin Money Lost **($/year)** | Mean Yellow Time (System survives on 1 out of two) **(%)** | Mean Yellow Time For Cutbacks Converted To Downtown **(hours/yr)** | Mean Repair Time **(days/ failure)** | Maintenance Actions From Table 3 **(#/yr)** | Cutback Conditions Gross Margin Failure Cost Losses **($/yr)** | Gross Margin Losses From Cutbacks and Total System Failures **($/yr)** | Pump Mainte-nance Repair Costs **($/yr)** | Sum Of Gross Margin Losses & Repair Costs **($/yr)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **a** | **b** | **c** | **d** | **e** | **f** | **g** | **h** | **I** | **j** | **k** | **l** | **m** | **n** |
| | | From RAPTOR | 365*(c/100)*24 | From RAPTOR | $10,000*d | From RAPTOR | 365*(g/100)*24 | From RAPTOR | h/(I*24) | $3,000*h | f + k | $10,000*(e + | L + N |
| 1 | 365 | 0.002808 | 0.245981 | 0.009 | $2,460 | 1.496662 | 0.0000 | 1.621665 | 2.788095 | $0 | $2,460 | $27,971 | $30,431 |
| 2 | 730 | 0.003180 | 0.278568 | 0.018 | $2,786 | 1.525694 | 0.0000 | 1.645328 | 2.648978 | $0 | $2,786 | $26,670 | $29,455 |
| 3 | 1095 | 0.002636 | 0.230914 | 0.016 | $2,309 | 1.523991 | 0.0000 | 1.591735 | 2.604294 | $0 | $2,309 | $26,203 | $28,512 |
| 4 | 1460 | 0.002888 | 0.252989 | 0.013 | $2,530 | 1.540243 | 0.0000 | 1.641320 | 2.714365 | $0 | $2,530 | $27,274 | $29,804 |
| 5 | 1825 | 0.003342 | 0.292759 | 0.018 | $2,928 | 1.558373 | 0.0000 | 1.658373 | 2.567228 | $0 | $2,928 | $25,852 | $28,780 |
| 6 | 2190 | 0.005548 | 0.486005 | 0.024 | $4,860 | 1.652372 | 0.0000 | 1.680495 | 2.571034 | $0 | $4,860 | $25,950 | $30,810 |
| 7 | 2555 | 0.003415 | 0.299154 | 0.019 | $2,992 | 1.588985 | 0.0000 | 1.692783 | 2.629023 | $0 | $2,992 | $26,480 | $29,472 |
| 8 | 2920 | 0.006000 | 0.525600 | 0.019 | $5,256 | 1.676827 | 0.0000 | 1.759163 | 2.508935 | $0 | $5,256 | $25,279 | $30,535 |
| 9 | 3285 | 0.004139 | 0.362576 | 0.025 | $3,626 | 1.534075 | 134.3850 | 1.708342 | 2.604980 | $0 | $3,626 | $26,300 | $29,926 |
| 10 | 3650 | 0.002161 | 0.189304 | 0.016 | $1,893 | 1.586171 | 138.9486 | 1.618912 | 2.612981 | $0 | $1,893 | $26,290 | $28,183 |
| 11 | 4015 | 0.008591 | 0.752572 | 0.034 | $7,526 | 1.530274 | 134.0520 | 1.643702 | 2.456795 | $0 | $7,526 | $24,908 | $32,434 |
| 12 | 4380 | 0.003305 | 0.289518 | 0.019 | $2,895 | 1.507384 | 132.0468 | 1.568182 | 2.511686 | $0 | $2,895 | $25,307 | $28,202 |
| 13 | 4745 | 0.004369 | 0.382724 | 0.018 | $3,827 | 1.560153 | 136.6694 | 1.629170 | 2.708196 | $0 | $3,827 | $27,262 | $31,089 |
| 14 | 5110 | 0.004655 | 0.407778 | 0.023 | $4,078 | 1.607977 | 140.8588 | 1.725438 | 2.750358 | $0 | $4,078 | $27,734 | $31,811 |
| 15 | 5475 | 0.005434 | 0.476018 | 0.022 | $4,760 | 1.678712 | 147.0552 | 1.694653 | 2.552981 | $0 | $4,760 | $25,750 | $30,510 |
| 16 | 5840 | 0.005960 | 0.522096 | 0.019 | $5,221 | 1.566482 | 137.2238 | 1.145008 | 2.646048 | $0 | $5,221 | $26,650 | $31,871 |
| 17 | 6205 | 0.005148 | 0.450965 | 0.019 | $4,510 | 1.566820 | 137.2534 | 1.641916 | 2.562249 | $0 | $4,510 | $25,812 | $30,322 |
| 18 | 6570 | 0.005380 | 0.471288 | 0.23 | $4,713 | 1.500112 | 131.4098 | 1.612780 | 2.676297 | $0 | $4,713 | $29,063 | $33,776 |
| 19 | 6935 | 0.005484 | 0.480398 | 0.019 | $4,804 | 1.556089 | 136.3134 | 1.646546 | 2.612177 | $0 | $4,804 | $26,312 | $31,116 |
| 20 | 7300 | 0.002263 | 0.198239 | 0.013 | $1,982 | 1.525871 | 133.6663 | 1.696846 | 2.550883 | $0 | $1,982 | $25,639 | $27,621 |
| | | | **Average =** | **0.030** | **$3,798** | | | | **2.614** | **$0** | **$3,798** | **$26,435** | **$30,233** |

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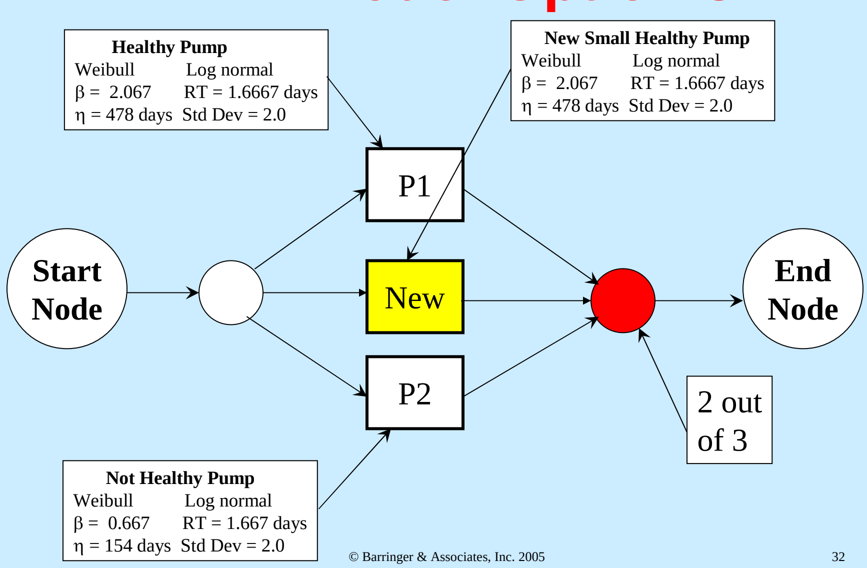
# RAM Model-Option 3

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# Summary Of Facts-Option 3

**Table 5-Failure Cost Details By Year**

**Alternate #2: Add Third Small Pump For $50,000 capital addition**

All results based on 1000 trials for each year---statistical data reported for only the year studied.

| Year | Days | Mean Red Time (two pumps down at same time), **(%)** | Mean Red Time Converted To Down Time For Total System Failures, **(hrs/year)** | Mean Number of Red Event System Failures. **(#)** | Mean Red Time For Complete System Failures Converted To Gross Margin Money Lost **($/year)** | Mean Yellow Time (System survives on 1 out of two) **(%)** | Mean Yellow Time For Cutbacks Converted To Downtown **(hours/yr)** | Mean Repair Time **(days/ failure)** | Maintenance Actions From Table 3 **(#/yr)** | Cutback Conditions Gross Margin Failure Cost Losses **($/yr)** | Gross Margin Losses From Cutbacks and Total System Failures **($/yr)** | Pump Mainte-nance Repair Costs **($/yr)** | Sum Of Gross Margin Losses & Repair Costs **($/yr)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **a** | **b** | **c** | **d** | **e** | **f** | **g** | **h** | **I** | **j** | **k** | **l** | **m** | **n** |
| | | From RAPTOR | 365*(c/100)*24 | | $10,000*d | From RAPTOR | 365*(g/100)*24 | From RAPTOR | h/(I*24) | $3,000*h | f + k | $10,000*(e + J | L + N |
| 1 | 365 | 0.005631 | 0.493276 | 0.024 | $4,933 | 1.493357 | 0.0000 | 1.621734 | 2.788095 | $0 | $4,933 | $28,121 | $33,054 |
| 2 | 730 | 0.006598 | 0.577985 | 0.034 | $5,780 | 1.522276 | 0.0000 | 1.645328 | 2.648978 | $0 | $5,780 | $26,830 | $32,610 |
| 3 | 1095 | 0.006315 | 0.553194 | 0.027 | $5,532 | 1.511053 | 0.0000 | 1.588076 | 2.604294 | $0 | $5,532 | $26,313 | $31,845 |
| 4 | 1460 | 0.005134 | 0.449738 | 0.023 | $4,497 | 1.542650 | 0.0000 | 1.641561 | 2.714365 | $0 | $4,497 | $27,374 | $31,871 |
| 5 | 1825 | 0.007489 | 0.656036 | 0.029 | $6,560 | 1.557925 | 0.0000 | 1.626821 | 2.567228 | $0 | $6,560 | $25,962 | $32,523 |
| 6 | 2190 | 0.008598 | 0.753185 | 0.041 | $7,532 | 1.640525 | 0.0000 | 1.679492 | 2.571034 | $0 | $7,532 | $26,120 | $33,652 |
| 7 | 2555 | 0.006485 | 0.568086 | 0.03 | $5,681 | 1.585399 | 0.0000 | 1.692950 | 2.629023 | $0 | $5,681 | $26,590 | $32,271 |
| 8 | 2920 | 0.007761 | 0.679864 | 0.032 | $6,799 | 1.646099 | 0.0000 | 1.748673 | 2.508935 | $0 | $6,799 | $25,409 | $32,208 |
| 9 | 3285 | 0.006247 | 0.547237 | 0.038 | $5,472 | 1.506308 | 131.9526 | 1.669873 | 2.604980 | $0 | $5,472 | $26,430 | $31,902 |
| 10 | 3650 | 0.004558 | 0.399281 | 0.032 | $3,993 | 1.561381 | 136.7770 | 1.621280 | 2.612981 | $0 | $3,993 | $26,450 | $30,443 |
| 11 | 4015 | 0.011695 | 1.024482 | 0.05 | $10,245 | 1.534922 | 134.4592 | 1.644482 | 2.456795 | $0 | $10,245 | $25,068 | $35,313 |
| 12 | 4380 | 0.008187 | 0.717181 | 0.035 | $7,172 | 1.548677 | 135.6641 | 1.609311 | 2.511686 | $0 | $7,172 | $25,467 | $32,639 |
| 13 | 4745 | 0.007047 | 0.617317 | 0.028 | $6,173 | 1.557050 | 136.3976 | 1.643827 | 2.708196 | $0 | $6,173 | $27,362 | $33,535 |
| 14 | 5110 | 0.008371 | 0.733300 | 0.036 | $7,333 | 1.606874 | 140.7622 | 1.707090 | 2.750358 | $0 | $7,333 | $27,864 | $35,197 |
| 15 | 5475 | 0.012698 | 1.112345 | 0.042 | $11,123 | 1.643722 | 143.9900 | 1.690501 | 2.552981 | $0 | $11,123 | $25,950 | $37,073 |
| 16 | 5840 | 0.009475 | 0.830010 | 0.028 | $8,300 | 1.598046 | 139.9888 | 1.654809 | 2.646048 | $0 | $8,300 | $26,740 | $35,041 |
| 17 | 6205 | 0.010576 | 0.926458 | 0.035 | $9,265 | 1.558653 | 0.0000 | 1.634686 | 2.562249 | $0 | $9,265 | $25,972 | $35,237 |
| 18 | 6570 | 0.007056 | 0.618106 | 0.036 | $6,181 | 1.506175 | 0.0000 | 1.612697 | 2.676297 | $0 | $6,181 | $27,123 | $33,304 |
| 19 | 6935 | 0.005098 | 0.446585 | 0.025 | $4,466 | 1.560881 | 0.0000 | 1.641412 | 2.612177 | $0 | $4,466 | $26,372 | $30,838 |
| 20 | 7300 | 0.009203 | 0.806183 | 0.038 | $8,062 | 1.604712 | 140.5728 | 1.675225 | 2.550883 | $0 | $8,062 | $25,889 | $33,951 |
| | | | **Average =** | **0.033** | **$6,755** | | | | **2.614** | **$0** | **$6,755** | **$26,470** | **$33,225** |





# Details For Life Cycle Cost

**Table 6: Cost Summary Data For Life Cycle Cost Calculations**

| Year | Cost Details | | | | Savings | |
|---|---|---|---|---|---|---|
| | Original Installation | After debottle-necking | Big new pump @ $75K | Little new pump @ $50K | Big new pump @ $75K | Little new pump @ $50K |
| 1 | $29,849 | $366,045 | $30,431 | $33,054 | $335,614 | $332,991 |
| 2 | $30,503 | $335,632 | $29,455 | $32,610 | $306,177 | $303,023 |
| 3 | $28,726 | $337,425 | $28,512 | $31,845 | $308,913 | $305,580 |
| 4 | $29,299 | $349,465 | $29,804 | $31,871 | $319,662 | $317,594 |
| 5 | $28,075 | $334,769 | $28,780 | $32,523 | $305,989 | $302,246 |
| 6 | $27,010 | $341,875 | $30,810 | $33,652 | $311,064 | $308,223 |
| 7 | $29,383 | $342,578 | $29,472 | $32,271 | $313,107 | $310,307 |
| 8 | $26,814 | $335,202 | $30,535 | $32,208 | $304,667 | $302,994 |
| 9 | $28,139 | $349,358 | $29,926 | $31,902 | $319,432 | $317,456 |
| 10 | $27,987 | $340,216 | $28,183 | $30,443 | $312,034 | $309,774 |
| 11 | $29,862 | $344,555 | $32,434 | $35,313 | $312,121 | $309,242 |
| 12 | $26,790 | $335,626 | $28,202 | $32,639 | $307,424 | $302,987 |
| 13 | $29,016 | $350,714 | $31,089 | $33,535 | $319,625 | $317,179 |
| 14 | $28,904 | $343,361 | $31,811 | $35,197 | $311,550 | $308,165 |
| 15 | $27,735 | $325,512 | $30,510 | $37,073 | $295,002 | $288,439 |
| 16 | $28,791 | $333,877 | $31,871 | $35,041 | $302,006 | $298,837 |
| 17 | $30,915 | $337,752 | $30,322 | $35,237 | $307,430 | $302,515 |
| 18 | $29,727 | $362,241 | $33,776 | $33,304 | $328,465 | $328,937 |
| 19 | $29,855 | $324,722 | $31,116 | $30,838 | $293,607 | $293,885 |
| 20 | $29,768 | $359,474 | $27,621 | $33,951 | $331,853 | $325,523 |
| Average= | $28,857 | **$342,520** | $30,233 | $33,225 | **$312,287** | **$309,295** |
| | **Cost Data** | | | | **Savings From Debottlnecking Datum** | |

# Final Results Of LCC Analysis

| Table 7: Financial Summary | | |
|---|---|---|
| Project Summary Based On Failure Data | | |
| | NPV | IRR |
| Big New Pump @ $75K | $1,388,368 | 233.1% |
| Small New Pump @ $50K | $1,400,134 | 354.1% |

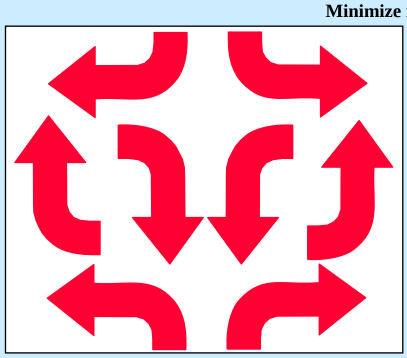
- NPV is positive. IRR exceeds 50%--winner is addition of a single small new pump

# Conflicting LCC Issues-- What To Do?

**Project Engineers:**
**Minimize capital expenditures**

**Maintenance Engineers:**
**Minimize repair hours**



**Shareholders:**
**Maximize dividends and/or share price**

**Production:**
**Maximize uptime hours**

**Reliability Engineers:**
**Maximize equipment reliability to avoid failures**

Buy right? Or Buy Cheap?

**Accounting:**
**Maximize project net present value**

# Engineers Must Quantify All Life Cycle Costs

Engineers Must Think Like MBA's
And
Act Like Engineers
To Get
Lowest Long Term Cost Of Ownership
Over The Entire Life Cycle

 Think NPV & IRR 

# What Goes Into Life Cycle Costs?

- Everything goes into LCC and each case is tailored for individual circumstances
- LCC follows a process that fits a simple tree for acquiring data

| Step | Task |
|---|---|
| 1 | Define the problem requiring LCC |
| 2 | Alternatives and acquisition/sustaining costs |
| 3 | Prepare cost breakdown structure/tree |
| 4 | Choose analytical cost model |
| 5 | Gather cost estimates and cost models |
| 6 | Make cost profiles for each year of study |
| 7 | Make break-even charts for alternatives |
| 8 | Pareto charts of vital few cost contributors |
| 9 | Sensitivity analysis of high costs and reasons |
| 10 | Study risks of high cost items and occurences |
| 11 | Select preferred course of action using LCC |

Feedback

## LCC Thumbnail

- Life cycle costs include cradle to grave costs
- Including failures into LCC decisions:
  - Engineering quantities of maintenance manpower,
  - Identify spare parts requirements + other resources
  - Use data for a rational decision rather than emotion
- LCC provides details for trade-off studies and uses NPV for sound decisions
- Monte Carlo models add realism to numbers and help find trade-off values

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## Remember---

- **Reliability engineering** tools analyze failure data to predict when failures will occur and the costs.
- You can't make a good life cycle cost analysis from poor data--LCC requires a team approach using many different sources of information and no one ever becomes a true LCC expert
- **LCC business decisions result in lower cost operating plants that are <u>truly cost effective</u> rather than just paper effective plants!**

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# Questions?

- Questions?

- For more examples and LCC aids visit: **http://www.barringer1.com**
- Download the LCC paper and slides as PDF files from **http://www.barringer1.com/Papers.htm**