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Engineering Analysis of Cost to Protect Workers from Diacetyl Exposure and the Economic Benefit of Noncompliance

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Abstract

Large commercial bakeries use artificial butter flavor (containing diacetyl) in its recipes, and have for more than 40 years. In 2012, a health-based exposure threshold was published for diacetyl by the American Conference of Governmental Industrial Hygienists (ACGIH). Bakery managers typically knew what was necessary to protect workers from exposure. However, for a variety of reasons, most did little to control exposure: The Food and Drug Administration said diacetyl was generally recognized as safe; substitute products had not been demonstrated as less harmful; and no regulatory standard had been established. This study develops the costs that would have been necessary to protect workers, using the U.S. EPA model (known as BEN) to calculate the economic benefit of noncompliance, and offers a characterization of the profit incentive to place workers at risk.

Keywords

Diacetyl, butter, bakery, noncompliance, bronchiolitis obliterans, respirators, ventilation, capital expense, return on investment, BEN, PEL, REL, TLV, STEL, forensic engineering

Introduction

Diacetyl (IUPAC* name butanedione or butane-2,3-dione) is a natural component of butter that can be artificially manufactured. Used in flavorings to add butter taste to popcorn, bakery products, and other consumer goods, it can also be found in coffee, beer, cigarettes, and other common consumer items. It has been shown to cause harm to workers who inhale diacetyl. In 2016, the National Institute of Occupational Safety and Health (NIOSH) published a Recommended Exposure Limit (REL)[1]. As of this writing, the Occupational Safety and Health Administration (OSHA) has not finalized a Permissible Exposure Limit (PEL). Litigation is not the topic of this paper. Instead, information learned will be used to develop what a company could have done, how much that would have cost, and (using one of U.S. Environmental Protection Agency's financial models, specifically BEN) calculate the economic benefit derived by not implementing controls.

While not a topic of this paper, the financial measures discussed may prompt other researchers to examine the ethical dilemma managers face when dealing with seemingly competing obligations to workers and owners.

The Hazard

In 1985, NIOSH published the results/conclusions of an investigation regarding two bakers who developed symptoms[2] suggestive of bronchiolitis obliterans (BO) disease. The report stated: "None of the chemical ingredients used in the mixes are known causes of bronchiolitis obliterans or emphysema"[2]. Diacetyl was used as an ingredient at that bakery; however, no specific etiology of the workers' disease was identified[2].

Popcorn plants came under scrutiny first, and much was learned about how to reduce exposure using engineering controls, administrative controls, and personal protective equipment. In 2000, employees at Gilster-Mary Lee popcorn plant in Jasper, Missouri became sick with a disease that was subsequently identified as BO, prompting the term "popcorn lung." As a result, the Missouri Department of Health and Senior Services requested a Health Hazard Assessment (HHA) in 2000 by NIOSH at the Gilster-Mary Lee plant[3]. While it took only a few months for NIOSH to begin work, it did not publish the

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* International Union of Pure and Applied Chemistry (https://iupac.org/)

HHA until completing the study in 2006. The NIOSH HHA sampled for diacetyl in the air at numerous popcorn plants. Subsequently, they found that workers with obstructive lung disease had been exposed to 3.3 times the national average workplace exposure to diacetyl. In 2000, NIOSH recommended a series of controls, including engineering controls, administrative controls, and personal protection equipment, that by 2006 (based on additional air monitoring) had significantly reduced exposure from butter flavor. While diacetyl was sampled, it was not identified as a chemical of concern in 2006.

In 2004, NIOSH published and widely distributed "ALERT: Preventing Lung Disease in Workers Who Use or Make Flavorings"[4]. NIOSH recommended:

1. Engineering controls:

a. Pollution prevention through substitution[¥].

b. Cover open containers of flavors and ingredients.

c. Use local and general ventilation to remove vapors from the workplace.

d. Isolate high-exposure process from the workers, and keep those spaces under negative pressure.

e. Maintain the temperature as low as practicable for the process.

2. Administrative controls:

a. Develop work practices and ensure compliance to limit vapor and dust emissions.

b. Monitor air concentrations and track progress to lowest level possible.

c. Keep Material Safety Data Sheets (MSDSs) up to date, and make sure containers are properly labeled.

d. Train employees regarding the potential hazards and how to protect themselves.

e. Use medical monitoring to evaluate employees when they are hired and follow up with routine monitoring to track employee health.

3. Personal protective equipment (PPE):

a. Provide respiratory protection when there is risk of exposure[£].

b. Provide other PPE such as gloves, masks, and goggles when there is risk of dermal exposure.

Soon thereafter, flavor manufacturers, especially those making butter flavor, became an industry of concern. In 2008, the International Brotherhood of Teamsters requested NIOSH perform a Health Hazard Evaluation (HHE)[¤] at a flavor manufacturing plant in Indiana because of its concern about flavor manufacturing, especially butter flavor. At that plant, the NIOSH HHE[5] found 3.8 times the number of workers with restricted lung function based on the most recent spirometry tests when compared to the general population of the United States. Again, engineering controls, administrative controls, and personal protective equipment were recommended to reduce exposure.

In response to a confidential employee request in 2005, NIOSH performed an HHE at a commercial bakery in Sacramento, California[6]. There was concern about skin rashes, dermatitis, coughing, and eye irritation. One employee had been diagnosed with Bakers' Asthma. Workers were exposed to flour dust and other allergens; some were exposed to more than the ACGIH threshold limit value (TLV[§]) for inhalable flour dust. The Occupational Safety and Health Administration (OSHA) did not specify a permissible exposure limit (PEL), nor did NIOSH specify a recommended exposure limit (REL) for flour dust. However, the OSHA limit for particulate not otherwise classified (PNOC) and the NIOSH REL for grain dust were both exceeded. Recommendations to control exposure were like those offered for control of diacetyl: engineering controls, administrative controls, and personal protective equipment. Note that the test for health effects from exposure to both diacetyl and flour dust is the same spirometry evaluation of lung capacity.

[¥] The health effects of known substitutes were not known. Caution was recommended because the state of science was such that these were unknowable at the time.

[£] Because there was no health-based threshold for safe exposure in 2006, proper respiratory protection could not be determined.

[¤] Health Hazard Evaluation (HHE) and Health Hazard Assessment (HHA) are terms with subtle differences that are not relevant for this discussion.

[§] A TLV is that concentration expected to be safe for workers to be exposed for an 8-hour work day and 40-hour work week. A PEL is a regulatory standard that is not be exceeded. The REL is a recommendation that is expected to keep workers safe over the workday and workweek.

Health-Based Standards

The Food and Drug Administration evaluated diacetyl in 1980, and determined that it was Generally Recognized as Safe (GRAS)[7]. The report evaluated ingestion as the route of exposure. Based on this federal regulation and the business confidential nature of flavor formulas, diacetyl was not normally listed as an ingredient on Material Safety Data Sheets (MSDSs). Therefore, this gave manufacturers and users of diacetyl a scientifically based reason to think this chemical was safe.

When a link was established between BO and butter flavor, industry, regulatory agencies, and scientific organizations rushed to establish a safe exposure concentration. Efforts by ACGIH, OSHA, and NIOSH are briefly discussed below. NIOSH is basically a research organization, and OSHA often accepts the REL for the PEL.

The ACGIH is a non-profit scientific organization that publishes TLVs as guidance. Since the ACGIH is not a regulatory agency, it can set "standards" more quickly, though ACGIH is also not a formal voluntary consensus standards developer. ACGIH uses a diverse committee of about 25 scientists who develop a list of chemicals under study. Each February 1, that list is published in two tiers: Tier 1 are chemicals likely to progress through standard development; Tier 2 chemicals are those not likely to progress. One or more of the committee members reviews the available literature focusing on concentrations that are at or near the "no effect" level, including a suggested TLV. This literature review is further reviewed by more members of the committee. When they reach a consensus, the review is presented to the full committee. Then it is presented to the Board of Directors. If approved, it is published as a Notice of Intended Change (NIC) on a subsequent February 1. The review period is strictly limited to four months, and ends on May 31. Absent substantial additional information, it is published along with the adopted documentation the following year. Diacetyl was published as a NIC in 2011. In 2012, a TLV for diacetyl was adopted and set at 0.01 ppm (0.04 mg/m^3)[8]. ACGIH also set a Short-Term Exposure Limit[$] (STEL) at 0.02 ppm (0.07 mg/m^3).

Perhaps due to political pressure, OSHA moved to regulate prior to NIOSH completing its work on diacetyl. On January 21, 2009, OSHA published an Advanced Notice of Proposed Rulemaking[9], setting a threshold for safe exposure. It was withdrawn three months later[10], when it was decided scientific peer review was necessary. It is interesting this was withdrawn before the comment period ended on April 21, 2009. In October 2009, OSHA initiated peer review of health effects and risk assessment. OSHA has not set a PEL for diacetyl to date. A NIOSH REL for diacetyl was not published until October 2016[1].

Unless and until there is a regulatory standard (PEL), the only enforcement action available to OSHA is the General Duty Clause of the Occupational Safety and Health Act, which reads:

"Each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees."[11]

This law charged the Administrator of the Occupational Safety and Health Administration with the authority and responsibility to enforce violations of this general duty in cases where a specific standard was not established.

Commercial Bakery

A particular large commercial bakery used flavors on two product lines to manufacture refrigerated dough. Some of the flavors contained diacetyl in varying concentrations, ranging from 0.002% to as high as 11%. The flavorings represented a very small amount in each product. Very little of the diacetyl-containing butter flavoring was mixed with the flavor mix, which made up a small portion of the dough. The amount of diacetyl in the final dough mix was on the order of 9.5 x 10^{-6} pound diacetyl/pound of dough.

As demonstrated by Dr. Rigler[12], diacetyl evaporates from any particular butter flavoring. Henry's Law shows that evaporation varies directly with temperature. Diacetyl emissions were reduced by cooler temperature in this refrigerated dough plant. Nonetheless, workers at this bakery were exposed and reported health consequences as a result.

Estimated Cost to Protect Workers

The necessary controls were well defined through the NIOSH publications cited above. They have been incorporated to reflect a typical large commercial bakery for the purposes of calculations in this paper. These companies are large, with average sales per plant of $12,857,153[13]. A large commercial bakery is defined as having more than 100 employees.

[$] A STEL is not to be exceeded for more than 15 minutes.

Cost of controls for this analysis were drawn from a report from Eastern Research Group (ERG) commissioned by OSHA in anticipation of regulatory action setting a PEL for diacetyl[14]. The author has calculated cost of controls numerous times, and the costs presented in the report are reasonable — however dated[15] – and sufficient for demonstrating the BEN model discussed later.

Following the link in the citation[14], the ERG report is available at www.regulations.gov. This website is a significantly expanded resource that makes available background and supporting documents for government regulations. The ERG Report has completed significant internal review by OSHA. However, it is marked "Draft Final Report" and cautions "Do Not Quote or Cite." The author understands OSHA does not intend to finalize this report. As briefly discussed above, OSHA has not published health-based thresholds for diacetyl. Supporting documentation for the NIOSH proposed recommended exposure level is, in the author's opinion, flawed. That may be a topic for another paper, but it is not within the scope of this paper.

Costs will be presented in the three control classifications: engineering controls, administrative controls, and personal protective equipment. Engineering controls include local exhaust and general ventilation and isolating equipment or processes.

Engineering Controls

Engineering controls are itemized in **Figures 1** and **2. Figure 1** includes a line item with equivalent annual costs (EAC) for all engineering controls. EAC is calculated using the following formula:

Some of the controls listed in the ERG Report were not included in the Figures. For example, converting mixers to mechanical systems had long since been completed for operational efficiency in most commercial bakeries. Therefore, it is not considered a cost of compliance.

$$EAC = \frac{NPV}{A}$$

Where; NPV = net present value

$$A = \frac{1 - \left[\frac{1}{(1+r)^t}\right]}{r}$$

Where; r = cost annualized at 7%

t = economic life

$A_{7\%,10y} = 7.02$

$A_{7\%,5y} = 4.10$

The additional equipment costs are process changes implemented to improve production, not control costs. Therefore, they are not included in the BEN analysis. They are included here for information and completeness.

Administrative Controls

For this discussion, administrative controls are used when engineering controls are not fully protective of workers. If the combination of engineering and administrative controls does not provide a sufficient margin of safety, personal protective equipment (PPE) is necessary.

The regulation envisioned by ERG as it prepared this report was developed through direct conversations with OSHA staff and review of an October 2007 internal draft of the proposed regulations of the final rule. These administrative controls included: exposure monitoring, medical surveillance, training, delineation of regulated areas, and an exposure control plan.

ERG developed annualized unit costs for each administrative requirement. These are identified in the Figures. Admittedly, some of the detail seems low. Data from 2006[16] and 2007[17, 18] were the basis for outdated wage and benefits ratios.

Exposure Monitoring

The draft regulation required establishing a baseline for exposure by monitoring if 50 workers are at risk of exposure for diacetyl and acetoin. The individual costs for this sampling are detailed in **Figure 3**.

Medical Surveillance

The draft regulation specifies medical surveillance for each at-risk employee. This would include a complete work history and respiratory questionnaire followed by a medical exam with spirometry test pre-employment and every six months. These costs are tabulated in **Figure 4**.

Training

The draft regulation required training to familiarize workers with the diacetyl standard, employers' exposure control plan, and medical surveillance plans. The estimated costs are tabulated in **Figure 5**.

Regulated Areas

This requirement of the draft regulation seems overly restrictive. It specified delineating areas wherever "a source of emission or potential employee exposure to

diacetyl, acetoin, or food flavorings or fragrances containing diacetyl or acetoin is reasonably expected." Details anticipated by ERG are tabulated in **Figure 6.**

Exposure Control Plan

The exposure control plan combines the other program costs, details the engineering controls, and incorporates the personal protective equipment in one plan and management effort. Becoming familiar with the program, developing the program, and writing it down are one-time costs. Administering the program and revising the program for process changes are a continuing effort. These are tabulated in **Figure 7**.

Annualized Costs for Administrative Controls

Annualized costs for administrative control are tabulated and totaled in **Figure 8**.

Personal Protective Equipment

ERG recommended full-face air-purifying respirators

Item	Reference	Number	Cubic Feet/Minute	Cost/Element	Total CFM	Costs
Drum Measuring/Mix Station	NIOSH, 2007[a]	8	1,200	$20,400	9,600	$163,200
Ventilated Small Batch Mixing Station	NIOSH, 2007[a]	8	800	$13,600	6,400	$108,800
Moveable Exhaust Hood	VS-90-02	8	1,050	$17,850	8,400	$142,800
Total					24,400	$414,800
Makeup Air ($3/CFM)						$58,560
Ventilation Capital Costs						$473,360
Engineering Design Costs						$33,135
Total Capital Costs						$506,495
Hours of Operation Factor						75%
Operating Costs				$2.43/CFM		$44,469
Maintenance (10% of capital costs)						$37,987
EAC (r =7%, n = 10)						$153,072
Other EAC (r = 7%; n = 5 or 10)						$15,432
Total EAC						$168,504

Figure 1
Enhanced ventilation costs.

with both an organic vapor cartridge and a particulate filter. Although NIOSH recommended gloves and goggles[4], ACGIH later published documentation for a diacetyl TLV[8] in which they cited only one study that referenced dermal exposure, with the comment that there were conflicting reports. Respirator costs are tabulated in **Figure 9**. A cost summary is shown in **Figure 10.**

Economic Benefit of Noncompliance

One of EPA's financial analysis models is BEN[19], which calculates the economic benefit of noncompliance for the various laws EPA administers. Others are:

° ABEL, which evaluates a corporation's or partnership's ability to afford compliance costs, cleanup costs, or civil penalties;

° INDIPAY, which evaluates an individual's ability to afford compliance costs, cleanup costs or civil penalties;

° MUNIPAY, which evaluates a municipality's or regional utility's ability to afford compliance costs, cleanup costs or civil penalties; and,

° PROJECT, which calculates the full cost to a

Other Control Equipment	Description	Equipment Cost	Operating Cost	Number of Units	Equipment Life	Capital Cost	Specifications
Covered Bucket	Stainless Steel Buckets	$110	$11	8	5	$880	13-quart Bucket and Lid
Tank Covers Small	Stainless Steel Cover for Tank, Custom Designed	$500	$50	8	5	$4,000	Approximate Costs Smaller Tanks
Tank covers Large	Stainless Steel Cover for Tank, Custom Designed	$2,000	$200	8	5	$16,000	Approximate Cost Larger Tanks
Spill Clean-up Kits	Spill Control Station	$350	$35	4	5	$1400	Quoted Price Suppler
Separate Mixing Rooms	1,000 ft^2 of 10 x 10 ft. wall and Industrial Door	$6,790	$679	4	10	$27,160	$4.89/$ft^2$ and $1,900/door
Reduce Water Pressure in Some Cleaning	Purchase Water Pressure Limiting Devices	$12	Negligible	8	5	$96	
Dopak® Closed Vent Sampler	3-Way Valve	$1,200	$120	4	10	$4,800	Needle Assembly and Valve

Figure 2
Additional equipment costs.

Item	Unit Costs	Detail
IH fees/8-hour PBZ[i] sample	$250.00	Consulting IH Technician, Daily rate $500
Lab Fees	$90.00	Per Sample
Samples Per 8-hour shift	4	Each for diacetyl and acetoin
Fee for blank	$90.00	1 blank for each set of samples
Sub-total Cost per sample	**$1,060.00**	Costs for both diacetyl and acetoin
Workers per sample	4	
Samples/year/worker for process change	0.1	
Time Requirements		
Worker productivity lost while sample pump is attached (hours)	0.5	
Manager Time per sample (h)	0.25	
Unit Cost per 8-hour sample	$1,080.00	
Initial Monitoring/worker annualized[ii]	$38.00	
Monitoring for process changes/worker annualized[iii]	$108.00	
If half of 100 employees are at- risk the annualized cost are	**$1,015.00**	(50 workers * 25% * $38) + (5 workers * $108) = $1015 (N = 10 years)

Figure 3
Exposure monitoring costs.

[i] Personal Breathing Zone (PBZ)
[ii] The underlying assumption is that 25% of at-risk employees would be monitored initially.
[iii] This assumes that 10% of the at-risk employees would be monitored each year for process changes.

Item	Cost	Detail
Spirometry test	$100.00	
Checkup	$80.00	
Medical History	0.75	Hours; first year only
Worker Time for test	1.00	Hours
Recordkeeping	0.25	Hours per worker tested
Initial exam per person	$222.70	
Subsequent exam per worker	$207.13	
Frequency (months)	6	
Annual Cost/worker	$416.33	
Average turn per year	30.1%	Percent of total employment (Bureau of Labor Statistics 2007)
Annual cost per worker adjusted for turnover	$514.53	
All 50 At-risk employees annual cost	**$25,726.50**	N = 10 years

Figure 4
Medical surveillance costs.

defendant of a proposed supplemental project in lieu of civil penalties.

These other models can be used to argue against the results of a BEN analysis. If there is sufficient interest, these will be presented in a subsequent paper.

As described by EPA:

"The U.S. Environmental Protection Agency developed the BEN computer model to calculate the economic benefit a violator derives from delaying and/or avoiding compliance with environmental statutes. In general, EPA uses the model to assist its own staff in developing

Item	Cost	Detail
Class Size	4	Employees
Training Time per session	0.5	hours
Materials	$2.00	Per employee per session
Instructors	1	Per class
Record keeping	0.02	Hours per worker trained
Training Frequency	1	Per year
Costs per worker	$17.69	
Annual cost for 50 workers	**$884.50**	N = 10 years

Figure 5
Training costs.

Item	Cost	Detail
Identify and establish regulated areas	16	Hours
Costs for hazard marking	$500	
Recurring admin requirements	32	Hours
Annual costs	**$2,244.00**	N = 10 years

Figure 6
Regulated areas cost.

Item	Cost	Detail
Rule familiarization	1	Hour
Develop program	16	Hour
Written program	8	Hour
Administer program	32	Hour
Revisions for process changes	16	Hour
Annualized costs	**$2,503**	N = 10 years

Figure 7
Exposure control plan costs.

Item	Annualized Cost	Detail
Exposure Monitoring	$1,015.00	
Medical Surveillance	$25,726.50	
Training	$884.50	
Regulated Areas	$2,244.00	
Exposure Control Plan	$2,503.00	
Annualized Cost for Administrative Controls	**$32,373.00**	**Non-Depreciable**

Figure 8
Annualized cost for administrative control.

settlement penalty figures. (For trial or hearing, an expert in financial economics must present the analysis of economic benefit, using whatever analytical tools — possibly including BEN, or maybe instead customized computer spreadsheets — are appropriate to the case's particular compliance scenarios.)

Calculating economic benefit using the BEN model is generally the first step in developing a civil penalty figure under EPA's February 16, 1984, generic penalty policy. This two- part document was codified in the General Enforcement Policy Compendium as P.T. 1-1 and P.T. 1-2. Related medium-specific policies have been developed since then to implement the 1984 policy. The BEN model assists in fulfilling one of the main goals of the generic policy. That goal is that civil penalties should at least recover the economic benefit from noncompliance to ensure that members of the regulated community have a strong economic incentive to comply with environmental laws on time."[19]

For civil litigation, the documented financial benefits of this model could certainly help attorneys and judges

Item	Cost	Detail
Equipment Cost	$237.50	Full-face air purifying respirator
Equipment Service Life	2	Years
Annualized Equipment Cost	$131.36	
Accessory Cost	$278.00	Includes organic vapor cartridge and particulate filter
Accessory Service Life	1	Year
Annualized Accessory Cost	$278.00	
Total Annualized Cost	$409.36	Equipment only
Training hours	2	Hours
Training Frequencies	1	Yearly
Annualized Training Costs	$61.08	
Fit Test Costs	$80.63	
Fit Test Frequency	1	Yearly
Annualized Fit Test Costs	$80.63	
Respirator Cleaning	$86.50	Five minutes for cleaning, fifty times per year
Total Annual Costs (each)	**$637.57**	Per at-risk employee
Total Annual Costs	**$31,878.50**	50 at-risk employees

Figure 9
Personal protective equipment cost.

Item	Cost	Detail
Capital Cost[i]	**$506,495**	Depreciable
Annual Operating & Maintenance Cost for Ventilation[ii]	**$83,551**	Includes some operating cost
Annualized Administrative Controls	**$32.373**	Non-depreciable
Annualized PPE	**$31,879**	Non-depreciable

Figure 10
Cost summary.

[i] Capital costs are adjusted for inflation and listed in the BEN model as Capital Costs.
[ii] The sum of Annual Operating & Maintenance Costs for Ventilation, Annualized Administrative Controls, and Annualized PPE are listed in the BEN model as non-depreciable expenses.

determine what amount of compensatory damages should be rewarded.

"You can use BEN in all cases to measure benefit from delayed and/or avoided compliance, except for Clean Air Act Section 120 actions, which require the application of a Section 120 specific computer model. BEN can calculate economic benefit for many types of organizations: corporations, partnerships, sole proprietorships, not-for-profit organizations, municipalities, and so forth. BEN is easy to use, even for people with no background in financial economics. Because the program contains standard values for many of the variables needed to calculate economic benefit, BEN requires only a small number of user inputs. BEN also allows the user to modify all of its standard values." [19]

Using the BEN model with this example calculates the following outputs, as shown in the printouts of the BEN model in the **Appendix**, are:

• For the delayed compliance[δ] from the date compliance was required to the date of penalty calculation: $1,224,258.

• For avoiding compliance altogether: $1,526,535.

The Opportunity Gain from noncompliance could be distributed in three separate ways:

• Paid out in management bonuses.

• Increased dividends to stockholders.

• Invested in additional production & automation equipment.

In conjunction with the BEN model (to determine the economic benefit of putting workers at risk), it would seem appropriate to determine the At Fault Company's return on investment (ROI) and factor that value (Opportunity Gain) on the economic benefit received for ignoring or delaying worker safety and health concerns.

The assumption here is that the company would alternatively invest those dollars into production and automation equipment and expect their normal or the industry standard return. The hurdle rate, which is also known as minimum acceptable rate of return (MARR), is the minimum required rate of return or target rate that companies are expecting to receive on an investment.

The following scenario uses a MARR of 10.41%, compounded over seven years (expected life of the equipment) which would be a conservative expected return for this industry.

In reality, rate of return (ROR) can easily be two to three times this percentage amount. The actual ROR of a Company in question would need to be assessed through a thorough financial analysis of their internal investment calculation model, and its corresponding ROR goal.

ROI (return on investment) is a common measure of profitability.[20]

$$\text{ROI} = \frac{\text{investment gain - investment cost}}{\text{investment cost}} \text{ x } 100\%$$

Annualized ROR using exact dates is typically more meaningful. Converting from ROI to ROR is most easily accomplished using one of the web-based calculators (IT Professionals 2008). For example, assuming a doubling of money over seven years;

$$\text{ROI delayed} = \frac{\$2{,}448{,}516 - \$1{,}224{,}258}{\$1{,}224{,}258} \text{ x } 100\%$$

= 100% over 7 yrs. yields an ROR = 10.41%

In this scenario, you could either present the $1,224,258 gain made as an additional economic benefit or use a 1.1041 multiplier, compounded over seven years, on the resulting BEN output.

$$\text{ROI avoided} = \frac{\$3{,}053{,}070 - \$1{,}526{,}535}{\$1{,}526{,}535} \text{ x } 100\%$$

= 100% over 7 yrs. yields an ROR = 10.41%

In this scenario, you could either present the $1,526,535 gain made as an additional economic benefit or use a 1.1041 multiplier, compounded over seven years, on the resulting BEN output.

Assuming these funds were invested in production equipment and automation, it is reasonable to expect a return on investment at an ROR OF 10.41%, would double the economic benefit amount calculated by the BEN model.

Conclusion

It costs time and money to implement effective environmental controls. This should be considered overhead; a necessary expense of production. Of course, funding such controls diminishes profits that can be distributed to

[δ]Delayed compliance was calculated from 01 May 2011 (date regulations effective) to 01 July 2017 (date selected arbitrarily to demonstrate delayed compliance).

owners. This paper shows how to calculate the real economic benefit that can result from not fully protecting workers.

Broader applications of this methodology may be useful to quantify the egregiousness of a harm that should have been prevented, or as a measure of unreasonableness of proactive efforts. These economic models have been effective in negotiating resolution of non-compliance with environmental regulations. This is a service engineers can offer attorneys.

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Appendix

Note: The inputs to the tables below have been modified by the program to reflect Discount/Compound rates calculations based on the values tabulated below the BEN runs. The model performs these calculations. Therefore, the inputs listed below do not copy the inputs discussed above.

	Run Name = NAFE3 Delayed
Present Values as of Noncompliance Date (NCO)	01-May-2011
A) On-Time Capital & One-Time Costs	$640,478
B) Delay Capital & One-Time Costs	$276,167
C) Avoided Annually Recurring Costs	$461,743
D) Initial Economic Benefit (A-B+C)	$826,055
E) Final Econ. Ben. at Penalty Payment Date, *01-Jul-2017*	$1,283,471

C-Corporation wl GA tax rates	
Discount/Compound Rate	7.4%
Discount/Compound Rate Calculated By:	BEN
Compliance Date	01-Jul-2017
Capital Investment:	
Cost Estimate	$560,831
Cost Estimate Date	01-May-2011
Cost Index for Inflation	PCI
Consider Future Replacement (Useful Life)	y (7)
One-Time. Nondepreciable Expenditure:	
Cost Estimate	$147,804
Cost Estimate Date	01-Nov-2011
Cost Index for Inflation	PCI
Tax Deductible?	y
Annually Recurring Costs:	
Cost Estimate	$147,804
Cost Estimate Date	01-Nov-2017
Cost Index for Inflation	PCI
User-Customized Specific Cost Estimates·	N/A
On-Time Capital Investment	
Delay Capital Investment	
On-Time Nondepreciable Expenditure	
Delay Nondepreciable Expenditure	

Discount/Compound Rate Calculation

Notes : (1) Corporate bond rates averaged across all industries (average of Aaa & Baa); Federal Reserve Statistical Release H.15.
(2) Combined state/federal marginal tax rates: federal+(state*(1-federal)); Federation of Tax Administrators.
(3) Calculated as: (1) * (100%-(2)). [Adjusts for tax-deductibility of interest payments.]
(4) Average corporate debt weight; Standard & Poor's Analysts' Handbook, S&P Industrials Sample Balance Sheet.
(5) Federal Reserve Statistical Release H.15. [Used as a proxy for the risk-free rate in the Capital Asset Pricing Model (CAPM)].
(6) Beta measures risk relative to overall stock market, with a value of 1.00 therefore setting risk at overall market.
(7) Differences of average returns between stock market vs. long-term Treasuries, 1926 - prior yr; Ibbotson then Duff & Phelps.
(8) Calculated as (6) * (7). [Also equal to (7), since (6) is equal to 1.00 for a company of average risk.]
(9) Calculated as (5) + (8). [Reflects risk-free rate of return plus the company risk premium.]
(10) Calculated as 100% - (4). [Reflects: total financing - debt = equity financing.]
(11) Calculated as (3) * (4) + (9) * (10). [Reflects: (debt cost x debt weight) + (equity cost x equity weight).]

Final rate:

						average from:		to:	=	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
YEAR	Cost of Debt	Tax Rate	After-Tax Debt Cost	Debt Weight	Long-Term Treasury Notes	Beta	Long-Horizon Risk Prem	Company Risk Premium	Equity Cost	Equity Weight	Rate
1987					8.49%	1.00	7.4%	7.4%	15.9%		
1988					8.91%	1.00	7.2%	7.2%	16.1%		
1989					8.47%	1.00	7.2%	7.2%	15.7%		
1990					8.58%	1.00	7.5%	7.5%	16.1%		
1991					8.00%	1.00	7.2%	7.2%	15.2%		
1992					7.34%	1.00	7.4%	7.4%	14.7%		
1993					6.29%	1.00	7.3%	7.3%	13.6%		
1994					7.49%	1.00	7.2%	7.2%	14.7%		
1995					6.95%	1.00	7.0%	7.0%	14.0%		
1996					6.83%	1.00	7.4%	7.4%	14.2%		
1997					6.69%	1.00	7.5%	7.5%	14.2%		
1998					5.72%	1.00	7.8%	7.8%	13.5%		
1999					6.20%	1.00	8.0%	8.0%	14.2%		
2000					6.23%	1.00	8.1%	8.1%	14.3%		
2001					5.63%	1.00	7.8%	7.8%	13.4%		
2002					5.43%	1.00	7.4%	7.4%	12.8%		
2003					4.96%	1.00	7.0%	7.0%	12.0%		
2004					5.04%	1.00	7.2%	7.2%	12.2%		

2005	4.64%	1.00	7.2%	7.2%	11.8%
2006	5.00%	1.00	7.1%	7.1%	12.1%
2007	4.91%	1.00	7.1%	7.1%	12.0%
2008	4.36%	1.00	7.1%	7.1%	11.5%
2009	4.11%	1.00	6.5%	6.5%	10.6%
2010	4.03%	1.00	6.7%	6.7%	10.7%
2011	3.62%	1.00	6.7%	6.7%	10.3%
2012	2.54%	1.00	6.6%	6.6%	9.1%
2013	3.12%	1.00	6.7%	6.7%	9.8%
2014	3.07%	1.00	6.96%	7.0%	10.1%
2015	2.55%	1.00	7.00%	7.0%	9.6%
2016	2.22%	1.00	6.90%	6.9%	9.1%

Calculations for Specific Cost Estimates

	On-Time	Delay
Date:	01-May-2011	01-Jul-2017
Capital Investment:		
Original Cost Estimate	$560,831	$560,831
	÷	÷
PCI Value as *of Cost Estimate Date, 01-May-2011*	581.900	581.900
	x	x
PCI Value as *of Specific Estimate Date*	581.900	551.517
	=	=
Specific Cost Estimate,	**$560,831**	**$531,548**
reflecting implicit annualized inflation rate of:	N/A	-0.9%
One-Time, Nondepreciable Expenditure:		
Original Cost Estimate	$147,804	$147,804
	÷	÷
PCI Value as *of Cost Estimate Date, 01-Nov-2011*	590.800	590.800
	x	x
PCI Value as *of Specific Estimate Date*	581.900	551.517
	=	=
Specific Cost Estimate,	**$145,577**	**$137,976**
reflecting implicit annualized inflation rate of:	3.1%	-1.2%

A) On-Time Capital & One-Time Costs	01-May 2011	01 – Nov 2011	01 – Nov 2012	01-Nov-2013	01-Nov-2014	01-Nov-2015	01-Nov-2016	01-Nov-2017	01-Nov 2018
One-Time, Nondepreciable Expenditure	(145,577)								
Capital Investment- Initial Installation	(560,831)								
Depreciation - Federal	0	(336,499)	(89,733)	(53,840)	(32,304)	(32,304)	(16,152)	0	0
Marginal Tax Rate (MTR)- Federal	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
Tax Liability Offset- Federal	50,952	117,775	31,407	18,844	11,306	11,306	5,653	0	0
Depreciation- State (GA)	0	(112,166)	(179,466)	(107,680)	(64,608)	(64,608)	(32,304)	0	0
MTR- State (GA), adj. for fed. deductibility	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
Tax li ability Offset- State (GA)	5,678	4,374	6,999	4,200	2,520	2,520	1,260	0	0
Net After-Tax Cash Flow	(649,779)	122,149	38,406	23,043	13,826	13,826	6,913	0	0
PV Factor: Adjusts Cash Flow to NCO	1.0000	0.9647	0.8980	0.8361	0.7785	0.7249	0.6748	0.6283	0.5850
PV Cash Flow as of NCO	{649,779)	117,831	34,489	19,267	10,764	10,022	4,665	0	0
Federal Utilized Depreciation Schedule:		60.00%	16.00%	9.60%	5.76%	5.76%	2.88%	0.00%	0.00%
State Utilized Depreciation Schedule:		20.00%	32.00%	19.20%	11.52%	11.52%	5.76%	0.00%	0.00%
Bonus schedules/dates (&'08 forward): MACRS:		20.00%	32.00%	19.20%	11.52%	11.52%	5.76%	0.00%	0.00%
10-Sep-01 6-May-03		*44.00%*	*22.40%*	*13.44%*	*8.06%*	*8.06%*	*4.03%*	*0.00%*	*0.00%*
5-May-03 1-Jan-05		*60.00%*	*16.00%*	*9.60%*	*5.76%*	*5.76%*	*288%*	*0.00%*	*0.00%*

Imputed Lease Cost for Interim Period When On-Time (But Not Delay) Equipment Would Need Replacement

				Start Date:	End Date:	Years:	Capital Cost:	Annual Lease:
Applicable Only w/ Default Value s of Delayed (Not Avoided) Capital and Considered Future Replacement				01-May-2018	01-Jul-2024	6.2	(541,386)	(101 ,861)
Total Imputed Lease Cost:	(631,539)	x	MTR- Federal/State Combined:	38.9%	=	Net After-Tax Cash Flow:		(385,870)
PV Factor: Adjusts Cash Flow to NCD:	0.4865							
PV Cash Flow as Of NCD· (187,738)		+	Initial Install. NPV (see above}: (452 740)		=	On-Time Total NPV Install+Lease: **(640,478)**		

B) Delay Capital & One-Time Costs	01-Jul-2017	01-Jan-2018	01-Jan-2019	01-Jan-2020	01-Jan-2021	01-Jan-2022	01-Jan-2023	01-Jan-2024	01-Jan -2025
One -Time, Nondepreciable Expenditure	(137,976)								
Capital Investment	(531,548)								
Depreciation- Federal	0	(318,929)	(85,048)	(51,029)	(30,617)	(30,617)	(15,309)	0	0
Marginal Tax Rate (MTR)- Federal	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
Tax Liability Offset- Federal	48,292	111,625	29,767	17,860	10,716	10,716	5,358	0	0
Depreciation - State (GA)	0	(106,310)	(170,095)	(102,057)	(61,234)	(61,234)	(30,617)	0	0
MTR- State (GA), adj. for fed. deductibility	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
Tax Liability Offset- State (GA)	5,381	4,146	6,634	3,980	2,388	2,388	1,194	0	0
Net After-Tax Cash Flow	(615,851)	115,771	36,400	21,840	13,104	13,104	6,552	0	0
PV Factor: Adjusts Cash Flow to NCO	0.6436	0.6209	0.5781	0.5383	0.5011	0.4665	0.4344	0.4045	0.3765
PV Cash Flow as of NCO	(396,368)	71,878	21,042	11,756	6,566	6,114	2,846	0	0
PV Cash FIQW as of NCO: (276,167)									
Federal Utilized Depreciation Schedule:		60.00%	16.00%	9.60%	5.76%	5.76%	2.88%	0.00%	0.00%
State Utilized Depreciation Schedule:·		20.00%	32.00%	19.20%	11.52%	11.52%	5.76%	0.00%	0.00%

C) Avoided Annually Recurring Costs

PCI value as of cost estimate date = 590.800

PCI mid-point value:	596.100	582.200	564.000	576.900	556.300	544.900	548.525
Period of Avoided Annual Costs; From:	01-May-2011	01-Jan-2012	01-Jan-2013	01-Jan-2014	01-Jan-2015	01-Jan-2016	01-Jan-2017
To:	31-Dec-2011	31-Dec-2012	31-Dec-2013	31-Dec-2014	31-Dec-2015	31-Dec-2016	01-Jul-2017
Annual Costs Avoided	(100,101)	(146,052)	(141,099)	(144,327)	(139,173)	(139,694)	(68,426)
Marginal Tax Rate	38.9%	38.9%	38.9%	38.9%	38.9%	38.9%	38.9%
Net After-Tax Cash Flow	(61,162)	(89,237)	(86,212)	(88,184)	(85,035)	(83,520)	(41,808)
PV Factor: Adjusts Cash Flow to NCD	0.9764	0.9198	0.8563	0.7973	0.7424	0.6912	0.6551
PV Cash Flow as of NCD	(59,720)	(82,079)	(73,825)	(70,311)	(63,129)	(57,727)	(27,389)

NPV of Avoided Annual Costs as of NCD **($434,180)**

Run Name= NAFE4 Avoided

Present Values as of Noncompliance Date (NCD)	01-May-2011
A) On-Time Capital & One-Time Costs	$640,478
B) Delay Capital & One-Time Costs	$0
C) Avoided Annually Recurring Costs	$434,180
D) Initial Economic Benefit (A-B+C)	$1,074,658
E) Final Econ. Ben. at Penalty Payment Date, *01-Jul-2017*	**$1,669.734**

C-Corporation w/ GA tax rates	
Discount/Compound Rate	7.4%
Discount/Compound Rate Calculated By:	BEN
Compliance Date	01-Jul-2017
Capital Investment:	avoided
Cost Estimate	$560,831
Cost Estimate Date	01-May-2011
Cost Index for Inflation	PCI
Consider Future Replacement (Useful Life)	*y* (7)
One-Time, Nondepreciable Expenditure:	avoided
Cost Estimate	$147,804
Cost Estimate Date	01-Nov-2011
Cost Index for Inflation	PCI
Tax Deductible?	y
Annually Recurring Costs:	
Cost Estimate	$147,804
Cost Estimate Date	01-Nov-2011
Cost Index for Inflation	PCI
User-Customized Specific Cost Estimates·	N/A
On-Time Capital Investment	
Delay Capital Investment	
On-Time Nondepreciable Expenditure	
Delay Nondepreciable Expenditure	

Discount/Compound Rate Calculation

Notes : (1) Corporate bond rates averaged across all industries (average of Aaa & Baa); Federal Reserve Statistical Release H.15.
(2) Combined state/federal marginal tax rates: federal+(state*(1-federal)); Federation of Tax Administrators.
(3) Calculated as: (1) * (100%-(2)). [Adjusts for tax-deductibility of interest payments.]
(4) Average corporate debt weight; Standard & Poor's Analysts' Handbook, S&P Industrials Sample Balance Sheet.
(5) Federal Reserve Statistical Release H.15. [Used as a proxy for the risk-free rate in the Capital Asset Pricing Model (CAPM)].
(6) Beta measures risk relative to overall stock market, with a value of 1.00 therefore setting risk at overall market.
(7) Differences of average returns between stock market vs. long-term Treasuries, 1926 - prior yr; Ibbotson then Duff & Phelps.
(8) Calculated as (6) * (7). [Also equal to (7), since (6) is equal to 1.00 for a company of average risk.]
(9) Calculated as (5) + (8). [Reflects risk-free rate of return plus the company risk premium.]
(10) Calculated as 100% - (4). [Reflects: total financing - debt = equity financing.]
(11) Calculated as (3) * (4) + (9) * (10). [Reflects: (debt cost x debt weight) + (equity cost x equity weight).]

Final rate:

					average from:			to:		=	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
YEAR	Cost of Debt	Tax Rate	After-Tax Debt Cost	Debt Weight	Long-Term Treasury Notes	Beta	Long-Horizon Risk Prem	Company Risk Premium	Equity Cost	Equity Weight	Rate
1987					8.49%	1.00	7.4%	7.4%	15.9%		
1988					8.91%	1.00	7.2%	7.2%	16.1%		
1989					8.47%	1.00	7.2%	7.2%	15.7%		
1990					8.58%	1.00	7.5%	7.5%	16.1%		
1991					8.00%	1.00	7.2%	7.2%	15.2%		
1992					7.34%	1.00	7.4%	7.4%	14.7%		
1993					6.29%	1.00	7.3%	7.3%	13.6%		
1994					7.49%	1.00	7.2%	7.2%	14.7%		
1995					6.95%	1.00	7.0%	7.0%	14.0%		
1996					6.83%	1.00	7.4%	7.4%	14.2%		
1997					6.69%	1.00	7.5%	7.5%	14.2%		
1998					5.72%	1.00	7.8%	7.8%	13.5%		
1999					6.20%	1.00	8.0%	8.0%	14.2%		
2000					6.23%	1.00	8.1%	8.1%	14.3%		
2001					5.63%	1.00	7.8%	7.8%	13.4%		
2002					5.43%	1.00	7.4%	7.4%	12.8%		
2003					4.96%	1.00	7.0%	7.0%	12.0%		
2004					5.04%	1.00	7.2%	7.2%	12.2%		

2005	5.65%	38.9%	3.45%	35.9%	4.64%	1.00	7.2%	7.2%	11.8%	64%	
2006	6.04%	38.9%	3.69%	32.8%	5.00%	1.00	7.1%	7.1%	12.1%	67%	
2007	6.02%	38.9%	3.68%	33.7%	4.91%	1.00	7.1%	7.1%	12.0%	66%	
2008	6.54%	38.9%	4.00%	45.0%	4.36%	1.00	7.1%	7.1%	11.5%	55%	
2009	6.30%	38.9%	3.85%	38.6%	4.11%	1.00	6.5%	6.5%	10.6%	61%	
2010	5.49%	38.9%	3.35%	36.7%	4.03%	1.00	6.7%	6.7%	10.7%	63%	
2011	5.15%	38.9%	3.15%	37.0%	3.62%	1.00	6.7%	6.7%	10.3%	63%	**7.7%**
2012	4.31%	38.9%	2.63%	35.9%	2.54%	1.00	6.6%	6.6%	9.1%	64%	**6.8%**
2013	4.67%	38.9%	2.85%	30.9%	3.12%	1.00	6.7%	6.7%	9.8%	69%	**7.7%**
2014	4.51%	38.9%	2.76%	30.9%	3.07%	1.00	6.96%	7.0%	10.1%	69%	**7.8%**
2015	4.45%	38.9%	2.72%	32.2%	2.55%	1.00	7.00%	7.0%	9.6%	68%	**7.4%**
2016	4.15%	38.9%	2.54%	32.2%	2.22%	1.00	6.90%	6.9%	9.1%	68%	**7.0%**

Calculations for Specific Cost Estimates

	On-Time	Delay
Date:	01-May-2011	01-Jul-2017
Capital Investment:		
Original Cost Estimate	$560,831	N/A
	÷	÷
PCI Value as of Cost Estimate Date,	581.900	N/A
01-May-2011	x	x
PCI Value as of Specific Estimate Date	581.900	N/A
	=	=
Specific Cost Estimate,	**$560,831**	**NIA**
reflecting implicit annualized inflation rate of:	N/A	N/A
One-Time, Nondepreciable Expenditure·		
Original Cost Estimate	$147,804	N/A
	÷	÷.
PCI Value as of Cost *Estimate Date,*	590.800	N/A
01-Nov-2011	**X**	**X**
PCI Value as of Specific Estimate Date	581.900	N/A
	=	=
Specific Cost Estimate,	**$145,577**	N/A
reflecting implicit annualized inflation rate:	3.1%	N/A

A) On-Time Capital & One - Time Costs	01-May-2011	01-Nov-2011	01-Nov-2012	01-Nov-2013	01-Nov-2014	01-Nov-2015	01-Nov-2016	01-Nov-2017	01-Nov -2018
One-Time, Nondepreciable Expenditure	(145,577)								
Capital Investment- Initial Installation	(560,831)								
Depreciation- Federal	0	(336,499)	(89,733)	(53,840)	(32,304)	(32,304)	(16,152}	0	0
Marginal Tax Rate (MTR)- Federal	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
Tax Liability Offset- Federal	50,952	117,775	31,407	18,844	11,306	11,306	5,653	0	0
Depreciation- State (GA}	0	(112,166}	(179,466}	(107,680)	(64,608)	(64,608)	(32,304)	0	0
MTR- State (GA), adj. for fed. deductibility	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
Tax Liability Offset- State (GA)	5,678	4,374	6,999	4,200	2,520	2,520	1,260	0	0
Net After-Tax Cash Flow	(649,779)	122,149	38,406	23,043	13,826	13,826	6,913	0	0
PV Factor: Adjusts Cash Flow to NCO	1.0000	0.9647	0.8980	0.8361	0.7785	0.7249	0.6748	0.6283	0.5850
PV Cash Flow as of NCO	(649,779)	117,831	34,489	19,267	10,764	10,022	4,665	0	0
Federal Utilized Depreciation Schedule:		60.00%	16.00%	9.60%	5.76%	5.76%	2.88%	0.00%	0.00%
State Utilized Depreciation Schedule:		20.00%	32.00%	19.20%	11.52%	11.52%	5.76%	0.00%	0.00%
Bonus schedules/dates (& '08 forward): MACRS:		20.00%	32.00%	19.20%	11.52%	11.52%	5.76%	0.00%	0.00%
10-Sep-01 6-May-03		*44.00%*	*22.40%*	*13.44%*	*8.06%*	*8.06%*	*4.03%*	*0.00%*	*0.00%*
5-May-03 1-Jan-05		*60.00%*	*16.00%*	*9.60%*	*5.76%*	*5.76%*	*2.88%*	*0.00%*	*0.00%*

Imputed Lease Cost for Interim Period When On-Time (But Not Delay) Equipment Would Need Replacement				Start Date:	End Date:	Years:	Capital Cost:	Annual Lease:
Applicable Only w/ Default Values of Delayed (Not Avoided) Capital and Considered Future Replacement				01-May-2018	01-Jul-2024	6.2	(541,386)	(101,861) Total
Imputed Lease Cost:	(631,539)	X	MTR- Federal/State Combined:	38.9%	=	Net After-Tax Cash Flow:		(385,870)
PV Factor: Adjusts Cash Flow to NCD:	0.4865							
PY Cash Flow as of NCD· (187,738)		+	Initial Install, NPV (see above): (452,740)		=	On-Time Total NPV. Install+Lease: **(640,478)**		

B} Delay Capital & One-Time Costs	01-Jul-2017	01-Jan-2018	01-Jan-2019	01-Jan-2020	01-Jan-2021	01-Jan-2022	01-Jan-2023	01-Jan-2024	01-Jan-2025
One-Time, Nondepreciable Expenditure	0								
Capital Investment	0								
Depreciation- Federal	0	0	0	0	0	0	0	0	0
Marginal Tax Rate (MTR)- Federal	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
Tax Liability Offset- Federal	0	0	0	0	0	0	0	0	0
Depreciation- State (GA)	0	0	0	0	0	0	0	0	0
MTR- State (GA}, adj. for fed. deductibility	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
Tax Liability Offset- State (GA)	0	0	0	0	0	0	0	0	0
Net After-Tax Cash Flow	0	0	0	0	0	0	0	0	0
PV Factor: Adjusts Cash Flow to NCD	0.6436	0.6209	0.5781	0.5383	0.5011	0.4665	0.4344	0.4045	0.3765
PV Cash Flow as of NCD	0	0	0	0	0	0	0	0	0

PV Cash Flow of NCD: 0

Federal Utilized Depreciation Schedule:	60.00%	16.00%	9.60%	5.76%	5.76%	2.88%	0.00%	0.00%
State Utilized Depreciation Schedule: ·	20.00%	32.00%	19.20%	11.52%	11.52%	5.76%	0.00%	0.00%

C) Avoided Annually Recurring Costs

PCI *value* as *of* cost *estimate date= 590.800*

PCI *mid-point value:*	596.100	582.200	564.000	576.900	556.300	544.900	548.525
Period of Avoided Annual Costs; From:	01-May-2011	01-Jan-2012	01-Jan-2013	01-Jan-2014	01-Jan-2015	01-Jan-2016	01-Jan-2017
To:	31-Dec-2011	31-Dec-2012	31-Dec-2013	31-Dec-2014	31-Dec-2015	31-0ec-2016	O1-Jul-2017
Annual Costs Avoided	(100,101)	(146,052)	(141,099)	(144,327)	(139,173)	(136,694)	(68,426)
Marginal Tax Rate	38.9%	38.9%	38.9%	38.9%	38.9%	38.9%	38.9%
Net After-Tax Cash Flow	(61,162)	(89,237)	(86,212)	(88,184)	(85,035)	(83,520)	(41,808)
PV Factor: Adjusts Cash Flow to NCO	0.9764	0.9198	0.8563	0.7973	0.7424	0.6912	0.6551
PV Cash Flow as of NCO	(59,720)	(82,079)	(73,825)	(70,311)	(63,129)	(57,727)	(27,389)

NPV of Avoided Annual Costs as of NCD	($434,180)