ADAMS ML021340149

ATTACHMENT 1

Backup Power for PWRs with Ice Condenser Containments and for BWRs with Mark III Containments under SBO Conditions: Impact Assessment

NRC Contract No. NRC-04-01-067
Task Order #3
Job Code Y-6406

May 1, 2002

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Prepared for
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission

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1. Objective and Scope

The objective is to support RES/DSARE in the development of a cost impact analysis in order to determine whether the proposed safety modifications being considered under GSI-189 are cost justified.

Costs (Impacts) are determined for the following cases:

1a. Costs for backup power to the hydrogen igniters for ice condenser and Mark III plants under SBO conditions: Base Case

1b. Costs for off-the-shelf portable diesel generator as backup power to the hydrogen igniters for ice condenser and Mark III plants during SBO conditions: Low Cost Sensitivity Case

2. Costs for backup power to the hydrogen igniters and air return fans for ice condenser (IC) plants under SBO conditions

3. Costs for Passive Autocatalytic Recombiners (PARs) for ice condenser plants and Mark III plants under SBO conditions

For these four cases, impacts are estimated for the following four attributes:

- Industry Implementation
- Industry Operation
- NRC Implementation
- NRC Operation

In addition to the sensitivity case that considers a low-cost alternative, namely Case 1b, other sensitivity cases are addressed, as noted below.

Except where noted, the guidance described in the Regulatory Analysis documents, NUREG/BR-0058, Rev. 3 [1] and NUREG/BR-184 (1997) [2], will be used.

The following assumptions apply to all 4 cases:

- All costs are expressed in 2002 dollars.
- For the “Operation” impacts, a 7% real discount rate is used, as recommended in NUREG/BR-0184.
- The remaining life of the average plant is assumed to be 40 years. This value was determined by adding 20 years (assumption of license renewal) to typically 20 years remaining on the plant’s current license.
- Outage replacement power costs are zero (when considering “Industry Implementation”) since it is assumed that installation of these backup power supplies can be accomplished while on-line and/or during normal outage time. A sensitivity assessment will consider the impact of extended outage costs.

- Rulemaking costs will be considered as minimal. This would be appropriate if the GS-189 effort gets folded into the current 10 CFR 50.44 rulemaking rebaselining effort. A sensitivity assessment will be included that assumes a major rulemaking effort.
- Costs will be determined “per unit,” with consideration of reduced per-unit costs for sites with dual units.
- The Catawba Unit 1 ice condenser plant and the Grand Gulf Mark III plant will be used as “typical” generic plants for the impact analysis.
- It is assumed that any rulemaking associated with the resolution of GI-189 will not affect the Station Blackout Rule or the License Renewal Rule.
- Consistent with the purpose of these options, namely to mitigate the consequences of severe accidents, the focus of equipment qualification will be the survivability of equipment, in contrast to meeting stringent design-basis requirements.

Certain other assumptions are relevant only to the backup power cases (Case 1a and 1b) and backup power plus air return fan case (Case 2):

- The backup power supplies will not be external event qualified. External event qualification costs will be considered as a variation on the Base Case (Case 1a).
- For both ice condenser plants and Mark III plants, one train of igniters is considered necessary and sufficient for accommodating hydrogen burns and preventing containment failure.
- The hardware (e.g., backup power generators) will meet the Category 3 standards and requirements of Regulatory Guide 1.97, Revision 3 [3], unless, for certain components, a higher category will be required. A functional unreliability (unavailability, unreliability, and associated human error) of 0.1 will be assumed for the Base Case in considering hardware, hardware location and timing for manual activation. Case 1b, a variation on the Base Case, considers minimal costs to provide backup power to the igniters. For this case the “functional reliability” of the backup power system will be less than that assumed for the Base Case. A value of 0.8 will be used, compared to the 0.9 value assumed in Case 1a. The implications of this are discussed in Appendix A (to be provided).
- For the case that considers the ice condenser air return fans (Case 2), one fan is considered as sufficient.
- The igniters are required to be powered for 48 hours.

The following assumptions are relevant to PARs only (Case 3):

- Since PARs will be installed in containments, and thereby could have impacts on safety equipment, they will be assumed seismically qualified for costing this assessment.
- It is estimated that an average of 40 half-sized PARs would be necessary and sufficient for both the ice condenser and the Mark III plants (to prevent containment failure from hydrogen burns).

2. Estimation and Evaluation of Impacts for the GI-189 Action

2.1 Base Case (Case 1a): Costs for Backup Power to the Hydrogen Igniters for Ice Condenser and Mark III Plants During SBO Conditions

The Base Case (Case 1a) is a modest but permanent modification that can provide backup power to igniters under SBO conditions. For the resolution of GI-189, the Base Case modification will include a prestaged diesel generator sized to power either one of the two trains of igniters. Due to ventilation, radiation and fire protection concerns as well as space limitations for location of the alternate power supply in the auxiliary building, it is more reasonable to locate the diesel generator outside, in an area that can be accessed by an operator. Because the alternate power supply is assumed not to be safety-related nor qualified for external events, the generator will not be housed in a separate structure. However, it is assumed that it will be designed for normal outdoor conditions, i.e., will be protected by a weather enclosure. Since the generator will be prestaged, the cost of the modification includes installation on a concrete slab. The powering of a train of igniters from the backup power supply is assumed to be manual and remote, that is, not powered from the control room.

For dual unit sites, an SBO event is postulated to impact only one unit. Therefore, at any given time, only one unit will require the alternate power source. The modification will be able to accommodate either unit, i.e., only one power supply will exist but with the capability to power either unit's igniters. The permanent modification consists of installation of cable, switches, and circuit breakers to permit the tie-in of the alternate power supply.

The existing power supply to the igniters is Class 1E, and typically rated at 120 V. The exact tie-in to the existing power supply would be plant specific, but for this case is assumed to occur at the last panel prior to the igniters. Therefore, the rating of the generator would be 120 V.

Each plant has a different number of igniters. The list below provides the total number of igniters per plant and the total power needed for one train of igniters.

Table 2-1 Igniter Data

Plant	Total Number of Igniters	Number of Igniters per Train	Total Power Needed for One Train of Igniters*
Catawba 1 and 2	70	35	4400 watts
McGuire 1 and 2	70	35	4400 watts
D.C. Cook 1 and 2	70	35	4400 watts
Sequoyah 1 and 2	68	34	4300 watts
Watts Bar 1	68	34	4300 watts
Grand Gulf	90	45	6000 watts**
River Bend	104	52	6500 watts
Clinton	115	58	7300 watts
Perry	To Be Provided		

* Assumes wattage of igniter is 125 watts
** Grand Gulf UFSAR indicates one train of igniters requires 6 kW

Industry Implementation

This attribute accounts for the projected incremental cost on the affected licensees to install or implement mandated changes. Cost elements such as engineering, materials and equipment, structures, installation, occupational exposure, procedures and training are considered. Other costs elements such as planning, scheduling, and procurement are included with the engineering costs.

Based on the information obtained from the IPEs and UFSARs, the approximate size of the generator needed to power one train of igniters ranges from 4.3 to 7.3 kW. Based on information obtained from different manufacturers, diesel generators (with weather enclosures) for the size needed range in cost from $4,000 to $13,000.

Duke recently supplied a cost estimate for this type of modification in response to an RAI [4] on a severe accident mitigation alternative (SAMA) for McGuire and Catawba. The cost for equipment and materials for a small diesel generator (~5 kW), cables, circuit breakers, concrete pad, and related items was estimated to be $50,000. This cost is adopted as representative of adding one independent power supply at a dual unit ice condenser plant. The cost at a single unit site is less because it will only require connections to one unit. For a single unit ice condenser plant, the estimate is $30,000. For the Mark III's, which require larger generators, the estimate is $35,000.

Installation, which involves connections to two units, was estimated by Duke to cost $110,000 which follows the standard that labor is about twice the cost of material. For the single unit IC, the estimate is $60,000, and for the Mark III, the estimate is $70,000.

Engineering was estimated by Duke to be $5,000 which appears to be a low figure. Other SAMA evaluations, past and recent, estimate engineering costs for similar modifications to be between $50,000 and $175,000 [5, 6]. A cost of $60,000 will be used for this analysis; this is applicable to dual-unit sites. For single unit IC's as well as the Mark III plants an engineering cost of $50,000 is used.

For the generators of interest, the fuel consumption rate is between 1 and 2 gallons per hour. Based on the assumption that the diesel will be required to operate for 48 hours, 50 to 100 gallons of diesel fuel will be required. Since the diesel does not have this fuel capacity, an additional tank, or means of supplying the fuel will be necessary. The cost associated with this is expected to be minimal, about $1,000. This cost has been added to the material and equipment cost element.

It is assumed that a connection/tie-in to the panel that powers the igniters will be necessary. The panels are typically located in the auxiliary building. The exposure rate for this specific location is not known; however, a dose rate of 5 mrem/hour is not unreasonable, considering the auxiliary building dose rates described in reference 10. Although labor estimates (hours) were not provided by Duke, an estimate of 48 hours x 2 persons is used for this evaluation. At a cost of $2,000/person-rem, the cost for occupational exposure due to installation at a dual-unit site is approximately $1,000, while at a single-unit site it is about $500. Dose rates outside the auxiliary building are assumed to be negligible.

According to several SAMA evaluations, the minimum cost for a procedure change and training is $30,000 [7]. This modification will require the development or modification of emergency procedures as well as training. Therefore, an estimate of $30,000 is used for this analysis for single-unit sites. Because of possible differences between the units at a dual-unit site, the dual-unit site costs are estimated to be $40,000.

For this case, it is assumed that the resolution of GI-189 will be subsumed by the 10 CFR 50.44 rulemaking. Therefore, it is likely that a change to the UFSAR would be appropriate. Licensee costs associated with a modification of this nature to the UFSAR are typically between $2,000 and $5,000. Here $3,000 is assumed. Again, as with procedure changes, the units at a dual-unit site may be sufficiently different that costs will be higher for those sites. Thus, the dual-unit costs are assumed at $4,000. Since the proposed modification does not involve any safety-related equipment, i.e., the equipment will be Category 3, no changes to the Technical Specifications are expected.

The table below contains a summary of the costs for Industry Implementation.

Table 2-2 Industry Implementation - Base Case (Case 1a)

Cost Element	Dual Unit IC	Single Unit IC	Mark III
Materials and Equipment	$51,000 $25,500/unit	$31,000	$36,000
Installation	$110,000 $55,000/unit	$60,000	$70,000
Engineering	$60,000 $30,000/unit	$50,000	$50,000
Worker Dose	$1,000 $500/unit	$500	$500
Emergency Procedures	$40,000 $20,000/unit	$30,000	$30,000
Licensing Costs	$4,000 $2,000/unit	$3,000	$3,000
Total for Industry Implementation	$266,000 $133,000/unit	$174,500	$189,500

Industry Operation

This attribute accounts for the projected incremental cost due to routine and recurring activities required by the proposed action on all affected licensees. The most notable costs considered are routine surveillance, maintenance and testing. Since the diesel generator will only be used in the event of SBO, periodic surveillance, testing and maintenance to ensure its operability will be necessary. It is assumed that quarterly surveillance and maintenance will be performed. Over a 40 year remaining life at a 7% real discount rate, this equates to approximately $3,200 [assumes 2 hours per quarter x $30/hour x 13.42 (40 years discounted to 2002) = $3,220]. As previously stated, dose rates in the test area are assumed to be negligible. Therefore, there is no occupational exposure associated with surveillance and maintenance.

NRC Implementation

This attribute measures NRC's incremental cost in implementing this regulatory change. Costs associated with a rulemaking and any review of licensee documentation are considered here. For the Base Case (Case 1a), it is assumed that the resolution of GI-189 will be included with the rulemaking effort for 10 CFR 50.44. In Reference 8, the cost estimated for a rulemaking of this type is $500,000. We assume that an additional incremental cost of $150,000 will be added to the rulemaking cost by adding the GI-189 action. This cost will be equally shared among the 13 units involved in the GI-189 action, thus yielding a per-unit cost of $11,500.

Since the equipment is not safety-related, no changes to the technical specifications will be necessary. However, changes to the UFSAR and PRA models are expected. NRC review of the UFSAR occurs every two years. Since the change will likely be submitted with the required update, the additional NRC cost should be minimal. Furthermore, since licensees do not typically submit their PRA models to the NRC for review, no additional NRC costs are assumed.

NRC Operation

This attribute measures NRC's incremental costs after the proposed action is implemented. As a result of the proposed action, there will be an increased effort during inspections. Assuming that an additional two-hour of inspection time is required annually, the total cost for NRC operation over 40 years is estimated to be $2,000 [based on an NRR labor rate of $80/hour].

Summary of Impacts for the Base Case (Case 1a)

The table below contains a summary of the impacts for the Case 1a, which is considered to be the Base Case.

Table 2-3 Summary of Impacts for the Base Case (Case 1a)

Attribute	Dual Unit IC	Single Unit IC	Mark III
Industry Implementation	$266,000 $133,000/unit	$174,500	$189,500
Industry Operation	$3,200 $1,600/unit	$3,200	$3,200
NRC Implementation	$23,000 $11,500/unit	$11,500	$11,500
NRC Operation	$2,000 $1,000/unit	$2,000	$2,000
Total for Case 1a (Base Case)	$294,200 $147,100/unit	$191,200	$206,200

2.1.1 Sensitivity Evaluations

In addition to considering a low-cost version of the Base Case (Case 1a), assessed as Case 1b, a number of other sensitivities are considered. All of these sensitivity cases are relative to the Base Case. The following evaluations were performed:

- Cost if the backup power supplies are qualified for external events
- Cost if GI-189 evolves into a separate and extensive rulemaking
- Cost if the industry implementation requires an extension of an outage
- Cost under the assumption of a 3% real discount rate instead of a 7% real discount rate

2.1.1.1 Sensitivity Case 1: Alternate Power Supply and Equipment is Qualified for External Events

If the alternate power supply and associated equipment (if located outdoors) are required to be qualified for external events, several of the cost elements are expected to increase significantly. Specifically, it is estimated, that the cost of the equipment would increase by a factor of three, the cost for installation would at least double, and the cost for engineering would double. All other costs are assumed to remain the same. These cost differentials are consistent with general cost trends experienced when a physical modification at a nuclear power plant is qualified for external events.

The adjusted numbers are given below. These numbers were extracted from the "Industry Implementation" table in the Base Case (Case 1a) above and adjusted.

Table 2-4 Industry Implementation - Sensitivity Evaluation: External Events

Cost Element	Dual Unit IC	Single Unit IC	Mark III
Materials and Equipment	$153,000 $76,500/unit	$93,000	$108,000
Installation	$220,000 $110,000/unit	$120,000	$140,000
Engineering	$120,000 $60,000/unit	$100,000	$100,000
Worker Dose	$1,000 $500/unit	$500	$500
Emergency Procedures	$40,000 $20,000/unit	$30,000	$30,000
Licensing Costs	$4,000 $2,000/unit	$3,000	$3,000
Total for Industry Implementation	$538,000 $269,000/unit	$346,500	$381,500

All other attributes remain the same as in the Base Case (Case 1a).

Table 2-5 Summary of Impacts for Sensitivity Evaluation: External Event Qualification

Attribute	Dual Unit IC	Single Unit IC	Mark III
Industry Implementation	$538,000 $269,000/unit	$346,500	$381,500
Industry Operation	$3,200 $1,600/unit	$3,200	$3,200
NRC Implementation	$23,000 $11,500/unit	$11,500	$11,500

Table 2-5 (Continued)

Attribute	Dual Unit IC	Single Unit IC	Mark III
NRC Operation	$2,000 $1,000/unit	$2,000	$2,000
Total for Sensitivity: External Event Qualification	$566,200 $283,100/unit	$363,200	$398,200

2.1.1.2 Sensitivity Case 2: If Separate Rulemaking is Required

The cost for a simple rulemaking is estimated to be $300,000. More complex rules can cost upwards of $1,000,000. It is likely that a rulemaking, although it affects only 13 units, would likely face opposition by the industry. Therefore, a cost of $400,000 is estimated for the rulemaking. On a per unit basis, this equates to approximately $30,800. The attribute that changes is "NRC Implementation"; all other attributes remain the same as the Base Case (Case 1a).

Table 2-6 Summary of Impacts for Sensitivity Evaluation: Rulemaking Required

Attribute	Dual Unit IC	Single Unit IC	Mark III
Industry Implementation	$266,000 $133,000/unit	$174,500	$189,500
Industry Operation	$3,200 $1,600/unit	$3,200	$3,200
NRC Implementation	$61,600 $30,800/unit	$30,800	$30,800
NRC Operation	$2,000 $1,000/unit	$2,000	$2,000
Total for Sensitivity: Rulemaking	$332,800 $166,400/unit	$210,500	$225,500

2.1.1.3 Sensitivity Case 3: If Extended Outage is Required

Although it is not anticipated that an extended outage would be necessary to accommodate the modification, it is possible that limited incremental downtime during a scheduled outage might occur. For the purpose of this sensitivity analysis, an incremental downtime of 8 hours is assumed. A typical number is $300,000 per day per unit [11], each day the unit is down. Therefore, it is expected that, for 8 hours of an extended outage, it would cost dual unit IC's $200,000, and the other units $100,000. The numbers below are extracted from the Base Case (Case 1a) above, and industry implementation is adjusted to account for a one-day extended outage.

Table 2-7   Summary of Impacts for Sensitivity Evaluation: Outage Extension

Attribute	Dual Unit IC	Single Unit IC	Mark III
Industry Implementation	$466,000 $233,000/unit	$274,500	$289,500
Industry Operation	$3,200 $1,600/unit	$3,200	$3,200
NRC Implementation	$23,000 $11,500/unit	$11,500	$11,500
NRC Operation	$2,000 $1,000/unit	$2,000	$2,000
Total for Sensitivity: Extended Outage	$494,200 $247,100/unit	$291,200	$306,200

2.1.1.4 Sensitivity Case 4: If a 3% Real Discount Rate is Used

For sensitivity analysis purposes, a 3% real discount rate is recommended [2] to assess the uncertainty in the time value of money. For 40 years the present-worth multiplier is 13.42, assuming 7%. Assuming 3%, the multiplier is 23.29. Thus, for the "Operation" attributes, the Base Case (Case 1a) numbers are multiplied by the ratio of these numbers, 1.735, to obtain the 3% numbers. However, because the costs associated with the operation attributes are relatively small, this adjustment has minimal effect on the total costs.

2.2 Case 1b: Costs for Off-the-Shelf Backup Power to the Hydrogen Igniters for Ice Condenser and Mark III Plants During SBO Conditions

This case is divided into two parts. The first part assumes that the licensees will volunteer to provide the backup power supply (Case 1b-1). The second part assumes that NRC has required a backup power system similar to the system volunteered by the licensees (Case 1b-2).

2.2.1 Case 1b-1: Volunteered

This case represents a lower bound sensitivity to establish the least expensive, yet feasible modification. It is assumed that for this case licensees will volunteer to provide the alternate means to power one train of igniters during SBO events. Therefore, a rulemaking would not be necessary. As such, and in keeping with the assumptions for the Base Case (Case 1a), there would be no changes to the technical specifications. It is further assumed that no changes to the UFSAR would be necessary. Licensees might be asked to send in a response stating that they have the means necessary to provide alternate power to the igniters.

Since the action would be voluntary, it is likely that licensees would choose a portable diesel that could be hooked up or attached within a short period of time. Permanent, but minor, modifications to the plant may be necessary to accommodate the hook up of the alternate power supply. Since the diesel generator is portable, there will be more manual actions involved in the hookup to the igniters, leading to a larger human unreliability value relative to the Base Case (Case 1a).

Although this alternative to the Base Case (Case 1a) is assessed here for accommodating internal events, it is important to note that portable diesel generators are rugged and could possibly survive external events, depending upon where and how they are stored.

As with the Base Case (Case 1a), for a dual unit plant, an SBO event is postulated to impact only one unit. Therefore, at any given time, only one unit will require the alternate power source. It is anticipated that the modification will be able to accommodate either unit, i.e., only one power supply will exist with the capability to power either unit's igniters.

Industry Implementation

This attribute accounts for the projected incremental cost on the affected licensees to install or implement mandated changes. Cost elements such as engineering, materials and equipment, structures, installation, occupational exposure, procedures and training are considered. Other costs elements such as planning, scheduling, and procurement are included with the engineering costs.

Referring to the Base Case (Case 1a), the portable diesel will need to be rated for 4.4 kW for the ice condenser plants, and as high as 7.3 kW for the Mark III plants. Based on information obtained from different manufacturers, portable (industrial) diesel generators for the size needed range in cost from $2,000 to $5,000. (Alternatives to diesel generators, e.g., gas-powered generators, are typically more expensive and therefore not considered further here.) Without the need for a concrete base, or housing for the diesel, materials costs, which are limited primarily to cable, switches and panels, are assumed to be small. For the IC's, the cost for equipment and material is estimated to be $14,000 for the dual-unit sites and $7,000 for the single-unit site. For Mark III's, the cost is estimated to be $9,000.

Installation costs are estimated to be between $15,000 and $30,000 since only minor modifications are anticipated. A value of $30,000 will be used for this assessment for the dual-unit IC plants and $16,000 for the other plants.

Engineering costs are expected to be less than $20,000. For this analysis, an estimate of $15,000 will be used for the single-unit sites, which is only 30% of what was considered in the Base Case (Case 1a). The engineering costs will be higher for the dual-unit sites; $20,000 is assumed.

For the generators of interest, the fuel consumption rate is between 1 and 2 gallons per hour. Based on the assumption that the diesel will be required to operate for 48 hours, 50 to 100 gallons of diesel fuel will be required. Since the diesel does not have this fuel capacity, an additional tank, or means of supplying the fuel will be necessary. The cost associated with this is expected to be minimal, about $1,000 and is added to the Materials and Equipment element.

It is assumed that a connection/tie-in to the panel that powers the igniters will be necessary. The panels are typically located in the auxiliary building. The exposure rate for this specific location is not known; however, a dose rate of 5 mrem/hour is not unreasonable, considering the auxiliary building dose rates described in reference 10. Consistent with the Base Case (Case 1a), an estimate of 48 hours x 2 persons is used for this evaluation. At a cost of $2,000/person-rem, the cost for occupational exposure due to installation at a dual-unit site is approximately $1,000 and $500 per one unit site. Dose rates outside the auxiliary building are assumed to be negligible.

According to several SAMA evaluations, the minimum cost for a procedure change and training is $30,000 [7]. This modification will require the development or modification of emergency procedures as well as training. Therefore, an estimate of $30,000 is used for this analysis for single-unit sites. Because of possible differences between the units at a dual-unit site, the dual-unit site costs are estimated to be $40,000.

Table 2-8 Industry Implementation - Case 1b-1

Cost Element	Dual Unit IC	Single Unit IC	Mark III
Materials and Equipment	$15,000 $7,500/unit	$8,000	$10,000
Installation	$30,000 $15,000/unit	$16,000	$16,000
Engineering	$20,000 $10,000/unit	$15,000	$15,000
Worker Dose	$1,000 $500/unit	$500	$500
Emergency Procedures	$40,000 $20,000/unit	$30,000	$30,000
Licensing Costs	$0	$0	$0
Total for Industry Implementation	$106,000 $53,000/unit	$69,500	$71,500

Industry Operation

This attribute accounts for the projected incremental cost due to routine and recurring activities required by the proposed action on all affected licensees. The most notable costs considered is routine surveillance, testing and maintenance. Since the diesel generator will only be used in the event of SBO, periodic surveillance, testing and maintenance to ensure its operability is likely. It is assumed that quarterly surveillance and maintenance will be performed. Over a 40 year remaining life at a 7% real discount rate, this equates to approximately $3,200 [assumes 2 hours per quarter x $30/hour x 13.42 (40 years discounted to 2002) = $3,220]. As previously stated, dose rates outside are assumed to be negligible. Therefore, there is no occupational exposure associated with surveillance and maintenance.

NRC Implementation

This attribute measures NRC's incremental cost in implementing this regulatory change. Costs associated with a rulemaking and any review of licensee documentation are considered here.

Because the action is assumed to be voluntary, a rulemaking would not be necessary. As such, there would be no changes to the technical specifications, and no changes to the UFSAR would be necessary. Licensees might be asked to send in a response stating that they have the means necessary to provide alternate power to the igniters. If so, there would be a minimal NRC effort to receive, verify, and post (to ADAMS) the licensees' response. A minimal cost of $1,000 is assumed for this case.

NRC Operation

This attribute measures NRC's incremental costs after the proposed action is implemented. As a result of the proposed action, there will be an increased effort during inspections. Assuming that an additional two hours of inspection time is required annually, the total cost for NRC operation over 40 years is estimated to be $2,000 (based on an NRR labor rate of $80/hour).

Table 2-9 Summary of Impacts for Case 1b-1 - Volunteered

Attribute	Dual Unit IC	Single Unit IC	Mark III
Industry Implementation	$106,000 $53,000/unit	$69,500	$71,500
Industry Operation	$3,200 $1,600/unit	$3,200	$3,200
NRC Implementation	$1,000 $500/unit	$1,000	$1,000
NRC Operation	$2,000 $1,000/unit	$2,000	$2,000
Total for Case 1b-1 (Volunteered)	$112,200 $56,100/unit	$75,700	$77,700

2.2.2 Case 1b-2: Required by NRC

This alternative assumes the exact same fix as that calculated under case 1b-1 except here the fix is an NRC requirement instead of a voluntary initiative. Only one of the "Industry Implementation" elements would change, namely "Licensing Costs." These costs would be the same as those for the Base Case (Case 1a). The only other cost attribute that would change would be "NRC Implementation." These costs would also be the same as those for the Base Case (Case 1a). In summary, the variation that considers the modification being required by NRC would have the following costs:

Table 2-10 Summary of Impacts for Case 1b-2 - NRC Required

Attribute	Dual Unit IC	Single Unit IC	Mark III
Industry Implementation	$110,000 $55,000/unit	$72,500	$74,500
Industry Operation	$3,200 $1,600/unit	$3,200	$3,200
NRC Implementation	$23,000 $11,500/unit	$11,500	$11,500

Table 2-10 (Continued)

Attribute	Dual Unit IC	Single Unit IC	Mark III
NRC Operation	$2,000 $1,000/unit	$2,000	$2,000
Total for Case 1b-2 (NRC-Required)	$138,200 $69,100/unit	$89,200	$91,200

2.3 Case 2: Costs for Backup Power to the Hydrogen Igniters and Air Return Fans for Ice Condenser Plants Under SBO Conditions

This case is similar to the Base Case (Case 1a) with the exception of the size of the diesel required, and it only applies to plants with ice condenser containments. Other information pertinent to powering an air return fan in addition to one train of igniters is discussed below.

The existing power supply to the air return fans is Class 1E, and typically rated at 480 V. The exact tie-in to the existing power supply would be plant specific, but for this case is assumed to occur at the 480 V motor control center or comparable power panel. Therefore, the rating of the generator would be 480 V. The most likely solution would be to purchase one generator and one step-down transformer such that the igniters could be powered by the same alternate diesel generator. The typical power needed for one train of igniters at ice condenser plants is 4,400 watts as indicated above. Air return fans require between 20 and 25 kW. Therefore, the size of the generator needed to power the igniters and the air return fan is between 25 and 30 kW.

Along with the assumptions above, the following is assumed:

- The igniters and air return fan will be required to run for 48 hours
- All modifications can be made on-line or during a planned outage

Industry Implementation

This attribute accounts for the projected incremental cost on the affected licensees to install or implement mandated changes.

Based on information obtained from different manufacturers, diesel generators (with weather enclosures) for the size needed at a 480 V rating are estimated to be between $15,000 and $25,000.

Duke recently supplied a cost estimate for this type of modification in response to an RAI [4] on a severe accident mitigation alternative (SAMA) for McGuire and Catawba. The cost for equipment and materials for a larger diesel generator (~30 kW), cables, circuit breakers, concrete pad, and other was estimated to be $210,000. This cost is adopted as representative of adding one independent power supply at a dual unit IC plant. The cost at a single unit site is less because it will only require connections to one unit. Thus, for a single unit ice condenser plant, this estimate would be $115,000.

Installation was estimated by Duke to cost $240,000. The additional $100,000 for installation (compared with the Base Case (Case 1a)) is assumed to be for routing of cable, installation of switches and other components for the air return fan. For the single unit IC, the estimate would be $160,000.

For the Base Case (Case 1a), engineering was estimated to be $50,000 for the single unit IC. Since it is assumed that additional engineering would be required for providing power to the air return fan, the estimate is increased to $75,000. For the dual-unit plants $90,000 is estimated.

For the generators of interest, the fuel consumption rate is between 5 and 7 gallons per hour. Based on the assumption that the diesel will be required to operate for 48 hours, 240 to 336 gallons of diesel fuel will be required. Since the diesel does not have this fuel capacity, an additional tank, or means of supplying the fuel will be necessary. The cost associated with this is expected to be minimal (approximately $2,000). This estimate is double the estimate in the Base Case (Case 1a). The cost is included in the Materials and equipment element.

It is assumed that a connection/tie-in to the panel that powers the igniters and the air return fans will be necessary. The panels are typically located in the auxiliary building. The exposure rate for this specific location is not known; however, a dose rate of 5 mrem/hour is not unreasonable, considering the auxiliary building dose rates described in reference 10. Although labor estimates (hours) were not provided by Duke, an estimate of 96 hours x 2 persons is used for this evaluation. At a cost of $2,000/person-rem, the cost for occupational exposure due to installation at a dual-unit site is approximately $2,000, while at a single-unit site it is about $1,000. Dose rates outside the auxiliary building are assumed to be negligible.

According to several SAMA evaluations, the minimum cost for a procedure change and training is $30,000. This modification will require the development or modification of emergency procedures as well as training. Therefore, an estimate of $30,000 is used for this analysis for single-unit sites. Because of possible differences between the units at a dual-unit site, the dual-unit site costs are estimated to be $40,000.

For this case, it is assumed that the resolution of GI-189 will be subsumed by the 10 CFR 50.44 rulemaking. Therefore, it is likely that a change to the UFSAR would be appropriate. Licensee costs associated with a modification of this nature to the UFSAR are typically between $2,000 and $5,000. Here $3,000 is assumed. Again, as with procedure changes, the units at a dual-unit site may be sufficiently different that costs will be higher for those sites. Thus the dual-unit costs are assumed at $4,000. Since the proposed modification does not involve any safety-related equipment, i.e., the equipment will be Category 3, no changes to the Technical Specifications are expected.

Table 2-11 Industry Implementation - Case 2

Cost Element	Dual Unit IC	Single Unit IC
Materials and Equipment	$212,000 $106,000/unit	$117,000
Installation	$240,000 $120,000/unit	$160,000
Engineering	$90,000 $45,000/unit	$75,000

Table 2-11 (Continued)

Cost Element	Dual Unit IC	Single Unit IC
Worker Dose	$2,000 $1,000/unit	$1,000
Emergency Procedures	$40,000 $20,000/unit	$30,000
Licensing Costs	$4,000 $2,000/unit	$3,000
Total for Industry Implementation	$588,000 $294,000/unit	$386,000

Industry Operation

This attribute accounts for the projected incremental cost due to routine and recurring activities required by the proposed action on all affected licensees. The costs for industry operation at IC plants are assumed to be the same as for Base Case (Case 1a).

NRC Implementation

This attribute measures NRC's incremental cost in implementing this regulatory change. The costs for NRC implementation are assumed to be the same as for Base Case (Case 1a), except that only the 9 ice condenser plants are considered. Thus, the cost of NRC implementation, namely $150,000, is divided by 9 plants, yielding $16,700 per unit.

NRC Operation

This attribute measures NRC's incremental costs after the proposed action is implemented. As a result of the proposed action, there will be an increased effort during inspections. The costs for NRC operation are assumed to be the same as for the Base Case (Case 1a).

Table 2-12 Summary of Impacts for Case 2

Attribute	Dual Unit IC	Single Unit IC
Industry Implementation	$588,000 $294,000/unit	$386,000
Industry Operation	$3,200 $1,600/unit	$3,200
NRC Implementation	$33,400 $16,700/unit	$16,700
NRC Operation	$2,000 $1,000/unit	$2,000
Total for Case 2	$626,600 $313,300/unit	$407,900

2.4 Case 3: Costs for Passive Autocatalytic Recombiners (PARs) for Ice Condenser and Mark III Plants Under SBO Conditions

This case considers installation of PARs in containment. Much of the information provided below is taken from Reference 8 and adjusted to reflect the containment designs of consideration.

Industry Implementation

This attribute accounts for the projected incremental cost on the affected licensees to install or implement mandated changes. It is estimated that an average of 40 half-sized PARs would be installed in each ice condenser and Mark III containment. The average purchase price per half-sized PAR is estimated to be $24,000 [9]. Although the ability exists to produce PARs domestically, currently, PARs are imported from Europe. The amount above is based on the cost of an imported PAR. Thus, the purchase cost equates to $960,000. Should a catalyst bed need to be replaced (due to test failure), a replacement bed would cost approximately $350 [9]. A few beds are likely to be purchased at the time the PARs are purchased. Therefore, an additional cost of $1,000/unit is likely. The catalyst beds need to be tested in a testing enclosure complete with sensing instrumentation and a computer. The current cost for such a testing apparatus is $10,000. Each plant would require a testing apparatus. Thus, the total estimated Materials and Equipment element for a single-unit site is $960,000 + $1,000 + $10,000 = $971,000. The corresponding total for the dual-unit sites is 2x($960,000) + 2x($1,000) + $10,000 = $1,932,000.

Installation costs will also vary depending on the area of the country (differing labor rates) in which the plant is located. At Indian Point 2, it cost approximately $100,000 to install two full-sized PARs [9]. Although the cost for installation is not expected to increase by 20 times, it is expected to increase by a factor of five (based on economies of scale). Thus, total labor costs are expected to be $500,000 per unit.

The engineering associated with installation of the PARs will vary depending on the intended location of the PARs and whether extensive modifications will be necessary to accommodate the PARs. Based on information provided in past SAMA evaluations, a recent response to a Request for Additional Information related to SAMA evaluations, and information obtained from Indian Point 2, engineering costs ranged from $35,000 to $400,000 [6, 9]. Assuming units at 2 unit sites are similar in design and layout, our estimate for engineering of the PARS is $150,000 which is independent of whether it is a single or dual unit site. This estimate is largely driven by the fact that the PARs will have to be seismically installed.

During installation, workers are expected to receive occupational doses. The dose rates assumed are based on those given for recombiners in NUREG/BR-0184 [2], which are 10 mrem/hour for PWRs and 20 mrem/hour for BWRs. For this assessment, an average of 15 mrem/hour will be used. Since many, if not all, of the PARs will be seismically installed, it is estimated that it will take two men 24 hours per PAR. At the dose rate assumed for 40 PARs, this equates to 28.8 person-rem. The total cost for occupational exposure is estimated to be $57,600 per unit.

The PARs, most probably, will be maintained as Category 3 components (As defined in Reference [3]). Testing and surveillance, although not required, would be recommended. A testing/surveillance procedure would need to be developed. Industry estimates for development of a procedure and its implementation (i.e., training) are a minimum of $30,000 [7]. However, the procedure for testing the PARs is not as complex as other procedures (such as emergency operating procedures), and has already been developed for Indian Point 2. The effort at Indian Point 2 cost approximately $2,000 [9]. However, this included the training of only two individuals. Since for the purposes of this analysis 40 PARs are going to be installed, it is likely that more than two individuals would be trained. Therefore, the estimated cost for developing and implementing the testing procedure at a typical plant is estimated to cost $3,000.

For this case, it is assumed that the resolution of GI-189 will be subsumed by the 10 CFR 50.44 rulemaking. Therefore, it is likely that a change to the UFSAR would be appropriate. Licensee costs associated with a modification of this nature to the UFSAR are typically between $2,000 and $5,000. Here $3,000 is assumed. Again, as with procedure changes, the units at a dual-unit site may be sufficiently different that costs will be higher for those sites. Thus, the dual-unit costs are assumed at $4,000. Since the proposed modification does not involve any safety-related equipment, i.e., the equipment will be Category 3, no changes to the Technical Specifications are expected.

Table 2-13 Industry Implementation - Case 3

Cost Element	Dual Unit IC	Single Unit IC	Mark III
Materials and Equipment	$1,932,000* $966,000/unit	$971,000	$971,000
Installation	$1,000,000 $500,000/unit	$500,000	$500,000
Engineering	$150,000** $75,000/unit	$150,000	$150,000
Worker Dose	$115,200 $57,600/unit	$57,600	$57,600
Emergency Procedures	$3,000 $1,500/unit	$3,000	$3,000
Licensing Costs	$4,000 $2,000/unit	$3,000	$3,000
Total for Industry Implementation	$3,204,200 $1,602,100/unit	$1,684,600	$1,684,600

*Assumes testing apparatus is shared by both units
**Assumes units are similar in design and layout

Industry Operation

This attribute accounts for the projected incremental cost due to routine and recurring activities required by the proposed action on all affected licensees.

The only expected operation costs associated with the PARs after installation will be due to testing. One catalyst bed per PAR should be tested periodically. It is estimated that it will take a technician 0.5 hour to remove a catalyst bed, observe the PAR for any fouling (accumulation of dirt, debris, dust), then reinstall it after testing [9]. The total time estimated for performing the test, including transportation time, paper work, etc., is one hour per PAR [9]. This process involves two persons. Therefore, the total labor cost involved with testing a PAR is estimated to be $200/PAR, assuming a labor rate of $100/hour [9]. Since it is recommended that 1/4th of the PARs be tested every refueling outage [9], this equates to approximately $1,333 per year per plant based on an 18-month refueling cycle. Using the multiplier of 13.42 to determine the year 2002 cost equivalent, the cost is $18,000.

Testing also involves the passing of a known concentration of hydrogen gas across the catalyst bed. A cylinder of hydrogen would be required to perform the testing. At Indian Point 2, it cost approximately $100/PAR for the hydrogen [9]. Therefore, at a PWR considered by this analysis, the cost for hydrogen per year is estimated to be $700 ($100/PAR x 10 x 12/18 = $667). Again, using the multiplier of 13.42 to determine the year 2002 cost equivalent, the cost is $9,400.

The last expected cost associated with testing of the PARs is a calibration of the testing unit once every six years. Assuming 7 tests over the 40 year remaining life of the plant and a cost per test of $3,000, the approximate cost for calibration will be approximately $10,000.

NRC Implementation

This attribute measures NRC's incremental cost in implementing this regulatory change. Costs associated with a rulemaking and any review of licensee documentation are considered here. For Case 3, it is assumed that the resolution of GI-189 will be included with the rulemaking effort for 10 CFR 50.44. In Reference 8, the cost estimated for a rulemaking of this type is $500,000. We assume that an additional incremental cost of $150,000 will be added to the rulemaking cost by adding the GI-189 action. This cost will be equally shared among the 13 units involved in the GI-189 action, thus yielding a per-unit cost of $11,500.

Since the equipment is not safety-related, no changes to the technical specifications will be necessary. However, changes to the UFSAR and PRA models are expected. NRC review of the UFSAR occurs every two years. Since the change will likely be submitted with the required update, the additional NRC cost should be minimal. Furthermore, since licensees do not typically submit their PRA models to the NRC for review, no additional NRC costs are assumed.

NRC Operation

This attribute measures NRC's incremental costs after the proposed action is implemented. As a result of the proposed action, there will be an increased effort during inspections. This Increase is expected to be small, and not quantified in detail for the purposes of this analysis. An additional inspection cost of about $1,000/year is not unreasonable. Thus, the 2002 cost equivalent is $13,400.

Table 2-14 Summary of Impacts for Case 3

Attribute	Dual Unit IC	Single Unit IC	Mark III
Industry Implementation	$3,204,200 $1,602,100/unit	$1,684,600	$1,684,600
Industry Operation	$74,800 $37,400/unit	$37,400	$37,400
NRC Implementation	$23,000 $11,500/unit	$11,500	$11,500

Table 2-14 (Continued)

Attribute	Dual Unit IC	Single Unit IC	Mark III
NRC Operation	$26,800 $13,400/unit	$13,400	$13,400
Total for Case 3	$3,328,800 $1,664,400/unit	$1,746,900	$1,746,900

2.5 Presentation of Results

The results are presented in table format below. Note that the "sensitivity" cases reflect changes to the Base Case (Case 1a).

Table 2-15 Summary of Results

Case	Dual Unit IC Per Unit	Single Unit IC	Mark III	Industry*
Case 1a: Base Case	$147,100	$191,200	$206,200	$2,192,800
Sensitivity 1: External Event	$283,100	$363,200	$398,200	$4,220,800
Sensitivity 2: Rulemaking	$166,400	$210,500	$225,500	$2,443,700
Sensitivity 3: Extended Outage	$247,100	$291,200	$306,200	$3,492,800
Case 1b-1: Low Cost Fix "Volunteered"	$56,100	$75,700	$77,700	$835,300
Case 1b-2: Low Cost Fix "NRC Required"	$69,100	$89,200	$91,200	$1,006,800
Case 2: Igniters + ARF	$313,300	$407,900	$0	$2,914,300
Case 3: PARs	$1,664,400	$1,746,900	$1,746,900	$22,049,700

* 8 IC units at dual-unit sites, 1 IC unit at single-unit site, and 4 Mark III units at single-unit sites

It should be noted that the significant figures indicated in the results are retained only to allow for cross-checking and independent verification. When considering uncertainties, one significant figure would be more appropriate. For example, the "Industry" cost for the Base Case (Case 1a) is about $2M and the cost approximately doubles to $4M when including external event capability.

2.6 Summary

- The total industry cost (cost for 13 units) for the Base Case (Case 1a) is about $2M
- The cost about doubles to $4M when the backup power supply is qualified for external events
- Including a separate rulemaking only increases the cost (relative to the Base Case) by 11%

- If 8 hours of incremental outage time is assumed, the costs increase by about 60% (again, relative to the Base Case)
- There is virtually no additional cost when changing the real discount rate from 7% to 3%
- The "low-cost" option yields a cost that is about 30% of the Base Case cost. This percentage increases slightly to 36% when this option becomes a regulatory requirement
- The cost for the ice condenser PWRs more than doubles when the powering of the air-return fans is required
- The cost for PARS is about an order-of-magnitude higher than backup power under Base Case assumptions

3. References

1. "Regulatory Analysis Guidelines of the U.S. NRC," NUREG/BR-0058, Rev. 3, U.S. NRC, July 2000.
2. "Regulatory Analysis Technical Evaluation Handbook," NUREG/BR-0184, U.S. NRC, January 1997.
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6. Henig, Michael. <Michael_Henig@dom.com> "SAMA Questions Final Response" 22 January 2002. **[To be docketed]**
7. *Applicant's Environmental Report - Operating License Renewal Stage, Turkey Point Units 3 & 4*. Florida City, FL, September 2000.
8. "PAR Requirements for PWRs: Value Impact Assessment, Draft," ISL, Inc. January 2002.
9. Green, Kim. <kgreen@islinc.com> "Cost Information from Indian Point 2" 31 January 2002.
10. Beal, S.K., et al., "Data Base of System-Average Dose Rates at Nuclear Power Plants," Final Report, NUREG/CR-5035, 10/87.
11. VanKuiken, J. C., et al., "Replacement Energy Costs for Nuclear Electricity-Generating Units in the United States: 1997-2001," NUREG/CR-4012, 9/97.

Appendix A

Relationship Between Costs, Benefits and Functional Reliability: GI -189

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Costs, expressed in 2002 dollars, for the IC Base Case (Case 1a) and the IC Low-Cost Alternative Case (Case 1b) are considered here as a function of the "Functional Reliability" of the backup power supply. As used here, functional unreliability (1 minus the functional reliability) means "the probability that this function will not be successfully performed;" it includes the system unreliability, the system unavailability, and the human unreliability.

These costs are compared to the averted-risk benefit, also expressed in 2002 dollars, of the SBO backup power supply. In an NRC-sponsored study [A-1], a methodology is presented for allocating reliability and risk. A number of reliability cost functions are considered in this study, all with similar basic properties, namely:

- cost is a monotone increasing function of reliability
- derivative of cost with respect to reliability is a monotone increasing function of reliability
- cost of a high reliability component is very high

A curve with these basic properties is displayed in Figure A-1 for the case of an ice condenser unit at a dual-unit site (e.g., Catawba Unit 1). Three curve data points are also shown:

- The cost of the Base Case (Case 1a) backup power, with an assumed reliability of 0.9
- The cost of the Low Cost backup power, with an assumed reliability of 0.8
- The costs that would be incurred (sunk), independent of the reliability

The intent of this figure is only to show the general trend in cost and the relationship between two alternatives with different assumed functional reliabilities. It is not the intent to present a rigorous quantitative picture of reliability versus cost.

This cost is compared to the associated benefit in Figure A-2 for Catawba, Unit 1. This figure is presented for illustrative purposes only. A linear relationship between benefit (averted risk) and reliability is assumed. Note that there is a wide range of reliabilities where a backup power source would be cost beneficial, that is, the averted risk values are greater than the backup power costs. Also note that, independent of the backup power supply design options considered in this GI-189 assessment, the regulatory approach could, in principle, make use of a performance-based functional reliability criterion, say of 0.85, that the licensee could meet in any way it chose. Such an approach would entail specification of an oversight mechanism (combination of inspections and performance indicators) that provides appropriate ongoing assurance of achievement of this functional reliability criterion.

References

[A-1] N. Z. Cho, et al., "A Methodology for Allocating Reliability and Risk," NUREG/CR-4048, BNL, May 1986.

Figure A-1 Relationship of Cost to Reliability

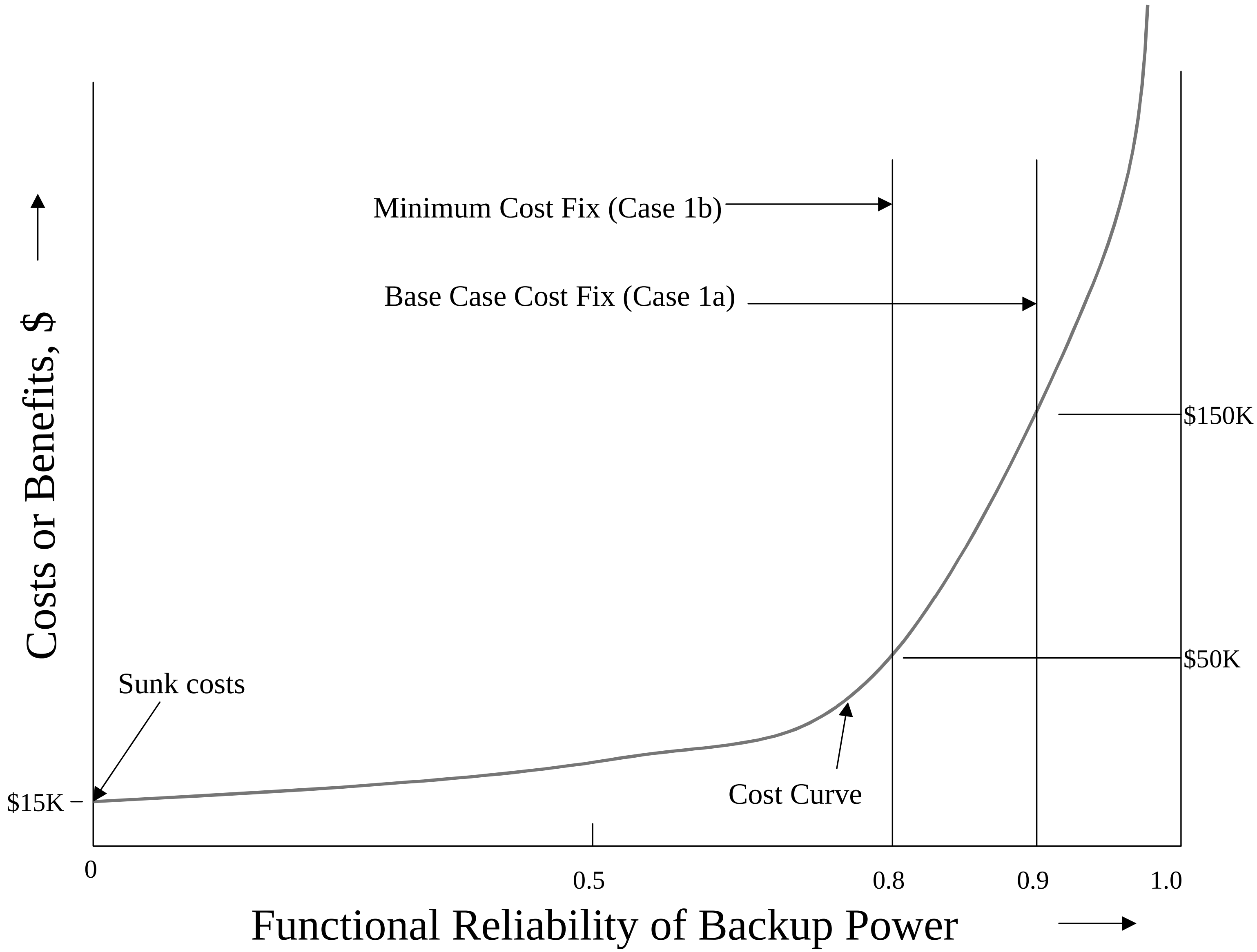

Figure A-2 Cost/Benefit vs Reliability: IC