Hospital Generator Pre-calculated Benefit-Cost Analysis

Methodology Report

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FEMA

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1. Executive Summary

The purpose of this analysis was to create a benefit-cost analysis (BCA) pre-calculated benefit for hospital generator projects under Federal Emergency Management Agency (FEMA) Hazard Mitigation Assistance (HMA) programs, similar to other existing pre-calculated benefits. The approach includes multiple assumptions, which were then applied to the existing FEMA hospital methodology.

This report outlines the inferences made and data referenced in creating the BCA pre-calculated benefit, and ultimately recommends hospitals estimate the benefits for generator hazard mitigation projects based on $6.95 per building gross square foot (BGSF) in urban areas and $12.62 in rural areas.

For example, a 180,000-square-foot rural hospital would have an estimated $2,271,600 in benefits using this pre-calculated benefit; if the project cost is less than $2,271,600, it would be considered cost-effective.

2. Introduction

Given the importance of hospitals and the number of individuals in hospitals who depend on power for their health and well-being, FEMA is focusing efforts on streamlining the application process for secondary measures for sources of power at hospitals. These efforts intend to expedite the application submission process and reduce the project review and approval time frame.

This methodology report presents a pre-calculated benefit for hospital generator projects. The use of pre-calculated benefits is reserved only to satisfy the cost-effectiveness requirement for eligible HMA projects. This does not affect other programmatic eligibility requirements under HMA programs.

3. Basis for the Pre-Calculated Benefit

The statutes that govern HMA programs include Stafford Act Sections 404 (HMGP) and 203 (PDM/BRIC) and the National Flood Insurance Act Section 1404 (FMA). These statutes require only that mitigation measures be determined to be cost-effective, but do not specify how cost-effectiveness should be determined.

Title 44 of Code of Federal Regulations (CFR) Parts 78.11 (FMA) and 206.434 (HMGP, note that PDM/BRIC do not have requirements outlined in regulations) also provide limited restrictions regarding how cost-effectiveness should be determined. The regulations state that projects must be cost-effective, meaning that they will "not cost more than the anticipated value of the reduction in both direct damages and subsequent negative impacts to the area if future disasters were to occur."

While the HMA guidance builds on the requirements outlined in the CFR and does state that cost-effectiveness is typically demonstrated by the calculation of a benefit-cost ratio (BCR), the calculation of a BCR is not required. This is also supported by the pre-calculated benefits that FEMA has implemented in recent years to streamline the grant application and review process.

The Office of Management and Budget (OMB) Circular A-94 policy provides guidelines for BCAs for grants administered by all federal programs. The policy outlines four elements of a cost-effective analysis, which are outlined in Table 1, and the hospital generator justifications that fulfill these four elements.

Table 1. Overview of OMB Circular A-94 Requirements for Cost-Effectiveness

Element	*Description*	*Comments*
Policy Rationale	Rationale for the program being examined should be clearly stated in the analysis. Justification may be where the policy improves the efficiency of the government's internal operations.	A BCA Pre-Calculated Benefit for hospital generator projects reduces the additional burden on FEMA to review the BCA when estimated costs are exceeded by the pre calculated benefits based on the methodology outlined in this report and streamlines grant reviews.
Explicit Assumptions	Analyses should be explicit about the underlying assumptions used to arrive at the estimates of benefits and costs.	This methodology report outlines the data sources, rationale, and assumptions used to arrive at the BCA pre-calculated benefit for hospital generator projects.
Evaluation of Alternatives	Analyses should also consider alternative means of achieving program objectives.	Alternative methodology approaches, including the benefits based on the population served, were considered.
Verification	Retrospective studies to determine whether anticipated benefits and costs have been realized are potentially valuable.	Approach was evaluated against recently reviewed and approved FEMA HMA hospital generator projects.

The hospital generator pre-calculated benefit was determined to align with OMB Circular A-94, as all elements of a cost-effective analysis are still satisfied. Therefore, implementation of a hospital generator BCA pre-calculated benefit is permissible per statutes, regulations, policies, and guidance.

4. Determining the Hospital Generator Pre-Calculated Benefit

The following sections outline how this hospital generator BCA pre-calculated benefit was determined. The determination of the pre-calculated benefit required evaluation of data from the American Hospital Association (AHA) and Pew Research Center, and the use of the existing hospital generator BCA methodologies. The data from these sources was used to calculate a new generator BCA pre-calculated benefit for rural and urban hospitals.

4.1. American Hospital Association and Pew Research Center Data

The AHA is a national organization representing and serving hospitals that conducts an annual survey within the United States. The methodology presented in this report used data from the AHA source, “Fast Facts on U.S. Hospitals, 2021”[1], particularly the total number of United States hospitals nationwide (6,090) and the number of total staffed beds nationwide (919,559).

Additional data related to hospital planning factors were incorporated into the methodology from “Facilities Planning for the Community Hospital of the Future”[2]. Specifically, it was estimated that the BGSF per hospital bed is between 2,000 and 2,250 for a community hospital with 150 beds.

Based on the data from AHA, it was assumed that the average hospital in the United States has 151 beds (919,599 beds divided by 6,090 hospitals), the average BGSF per hospital bed is 2,000, and the estimated hospital is 302,000 BGSF (2,000 BGSF times 151 beds).

Furthermore, the average population per hospital can be determined by dividing the population of the United States in 2021 (approximately 328,200,000) by the average number of hospitals nationwide (6,090) to obtain 53,891 people per hospital. The average hospital BGSF (302,000) divided by the average population per hospital (53,891) calculates to 5.6 BGSF per person.

The Pew Research Center is a nonpartisan organization informing the public about issues, attitudes, and trends by conducting public opinion polling, demographic research, content analysis, and other data-driven social science research.

In 2018, the Pew Research Center conducted surveys relating to how the distance Americans live from the closest hospital differs by community type. From the Pew Research Center source “How Far Americans Live from the Closest Hospital Differs by Community Type”[3], it was found that rural Americans live an average of 10.5 miles from the nearest hospital, compared with 5.6 miles for people in suburban areas and 4.4 for people in urban areas.

From this data, it was determined that, on average, rural American hospitals were at least 10.5 miles away from each other and urban hospitals were 5 miles away from each other, averaging suburban and urban distances.

4.2. Existing Hospital Generator Methodology

The existing methodology for estimating hospital loss of function has three unique BCA data inputs: primary hospital population, distance to nearest secondary hospital, and secondary hospital

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[1] Source: https://www.aha.org/statistics/fast-facts-us-hospitals, values as of July 12, 2021.

[2] Source: https://aharesourcecenter.wordpress.com/tag/hospital-bgsf-per-bed/, information as of July 12, 2021. Published on April 10, 2013.

[3] Source: https://www.pewresearch.org/fact-tank/2018/12/12/how-far-americans-live-from-the-closest-hospital-differs-by-community-type/, information as of July 12, 2021. Published December 12, 2018.

population. From these three data points, a total cost per day is generated based on the calculated costs of traveling extra distance, waiting time increases, and amplifying an injury over time.

Once the total cost per day is calculated, the next step in the BCA is determining the likelihood and duration of a loss of function for the hospital. This is done using impact days, recurrence intervals, and/or historical damage years. These values, combined with the previously generated total cost per day, are used to estimate the benefits.

4.2.1. CHALLENGES

There are several challenges associated with the retrieval and development of the existing required data inputs, especially for smaller hospitals with less funding. The required population served by the primary hospital is one such challenge. Often hospitals do not know their population served and it may be unclear where one hospital's population ends, and another begins.

It becomes more difficult when determining the population served by the closest secondary hospital because the secondary hospital must have the same capabilities as the primary hospital, requiring additional research into multiple nearby facilities. This is the same difficulty in determining the distance between the primary hospital and the secondary hospital.

4.3. New Hospital Generator Pre-Calculated Benefit

To alleviate the problems associated with using the primary hospital's population, an approach based on BGSF was selected. This is where the 5.6 BGSF per person value - based on data from the AHA and associated calculations - contributes to the methodology. Replacing the primary hospital population with BGSF gives both the subapplicant and FEMA a variable that is easy to determine and verify.

With the basis established for estimating the primary population, the remaining two hospital data inputs were secondary hospital population and distance between hospitals.

For the secondary hospital population, a substitute value/conservative assumption based on 75% of the primary population, now BGSF, was used. This decision was based on the limited effect the secondary hospital population had on the calculated benefits, especially for small to mid-sized hospitals.

This is considered a conservative approach because an equivalent or greater secondary hospital population would increase the total benefits generated. The hospital loss of function impact is estimated based on the wait time increase for the total population of the primary and secondary hospitals, which impacts the severity of injuries. This can be seen in the existing hospital BCA methodology and is available through the BC Helpline (bchelpline@fema.dhs.gov).

The next main driver of benefits to simplify - the distance between the primary hospital and secondary hospital - is important because it reflects the increased likelihood of a death/injury for every additional mile between the two hospitals. The average rural (10.5 miles) and urban (5 miles) distances previously estimated based on Pew Research Center survey data were used. This allows the subapplicant to choose between two different values based on the community type where the hospital is located.

To account for additional losses during a loss of function, displacement cost variables were added to the calculations. These variables come from the BCA modeled damages and, for hospitals, result in a recurring cost of $1.36 per BGSF per month, or $0.04 per BGSF per day, and a one-time displacement cost of $1.36 per BGSF.

This one-time displacement cost for before mitigation was used with varying percentages of cost based on the chance of a loss of function over 20 years: 25% of displacement costs for a 99% chance of failure, 75% of displacement costs for a 33% chance of failure, and 100% of displacement costs for a 10% chance of failure. For after mitigation a 10% chance for 25% displacement was used.

Having simplified the calculation for total cost per day, the remaining inputs to determine were recurrence intervals and impact days. For these, assumptions for estimating recurrence intervals and impact days were made based on existing estimated recurrence intervals and outage durations.

These estimated recurrence intervals and outage durations, which were estimated with input from electrical engineers, are often used when no other or insufficient documentation is available to support the probability of power outage for proposed generator projects. The estimated recurrence intervals and outage durations used are as follows:

- 5-year recurrence interval (99% chance over 20 years[4]) with a 1-day loss of function for before mitigation
- 50-year recurrence interval (33% chance over 20 years) with a 4-day loss of function for before mitigation
- 190-year recurrence interval (10% chance over 20 years) with a 7-day loss of function for before mitigation
- 190-year recurrence interval (10% chance over 20 years) with a 1-day loss of function for after mitigation

Once these variables were determined, the benefits calculations were used to develop a range of outcomes (Table 2). This table shows the benefits per BGSF centering around the average hospital BGSF and the two determined distances: 5 miles for urban areas and 10.5 miles for rural areas.

[4] 20 years is based on the FEMA standard project useful life (PUL) for a generator of 19 years but rounded to 20 years for ease of use. Recurrence intervals were properly scaled to match the increase in PUL.

Table 2. Calculations Using the Described BCA Methodology

Distance Between Hospitals (Miles)	*Square Footage*	*Before Mitigation: Frequent*	*Before Mitigation: Possible*	*Before Mitigation: Less Likely*	*After Mitigation: Less Likely*	*Benefits*	*Benefit Per BGSF*
5	210,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$1,448,106.40	$6.90
10.5	210,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$2,639,064.29	$12.57
5	240,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$1,659,223.92	$6.91
10.5	240,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$3,020,311.09	$12.58
5	270,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$1,871,390.24	$6.93
10.5	270,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$3,402,617.28	$12.60
5	300,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$2,084,626.56	$6.95
10.5	300,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$3,785,982.87	$12.62
5	330,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$2,298,922.28	$6.97
10.5	330,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$4,170,407.87	$12.64
5	360,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$2,514,266.81	$6.98
10.5	360,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$4,555,881.67	$12.66
5	390,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$2,730,681.33	$7.00
10.5	390,000	99.00% chance, 1 day loss of function	33.00% chance, 4 day loss of function	10.00% chance, 7 day loss of function	10.00% chance, 1 day loss of function	$4,942,414.87	$12.67

4.3.1. SELECTING THE HOSPITAL GENERATOR PRE-CALCULATED BENEFIT

As shown in Table 2, the benefit per BGSF for urban areas is $6.95 and the benefit per BGSF for rural areas is $12.62. These values differ slightly with different BGSF values, but not significantly. Therefore, these values are reasonable to use since they are based on the average BGSF of a hospital in the United States.

These estimated values are based on the average hospital size of 302,000 BGSF (rounded to 300,000 BGSF for ease of use in Table 2). The accuracy of these values was tested for hospitals of different sizes and it was found that for urban communities:

- $6.95 in benefits per BGSF is within a 1% accuracy for hospitals with a BGSF between 185,000 and 421,000
- $6.95 in benefits per BGSF is within a 2% accuracy for hospitals with a BGSF between 70,000 and 185,000 and between 421,000 and 543,000
- $6.95 in benefits per BGSF is within a 3% accuracy for hospitals with a BGSF below 70,000 and between 543,000 and 667,000

For rural communities:

- $12.62 in benefits per BGSF is within a 1% accuracy for hospitals with a BGSF between 88,000 and 516,000
- $12.62 in benefits per BGSF is within a 2% accuracy for hospitals with a BGSF below 88,000 and between 516,000 and 739,000

The benefits values should not be adjusted based on hospital size, as these are intended to be standard values based around average hospital size.

The benefits for rural communities are less sensitive to changes in BGSF because the greater distance between hospitals offsets the hospital size difference. For example, at a mile distance only 43% of the benefits are influenced by the distance between hospitals, while at 100 miles, 98% of the benefits are influenced by the distance between hospitals.

4.3.2. DETERMINING RURAL VERSUS URBAN AREAS

A map showing the urbanized areas and urban clusters based on the 2010 U.S. Census can be seen in Figure 1. This map and the associated definition for urbanized areas (an area having a population of 50,000 or more) were used to determine the classification for an urban area in this study. If the hospital is within an urbanized area, the community type is urban; otherwise, the community type is considered rural. Urban clusters are included in the rural community type for this analysis.

Community type should be determined on a location-specific basis; there can be multiple community types within a single county or metropolitan statistical area. Alaska, Hawaii, Puerto Rico, USVI, and other island territories are considered rural for the purposes of this methodology. This classification is based on the increased costs of materials and labor for these areas and because of remote/isolated nature.

5. Implementation of the Hospital Generator Pre-Calculated Benefit

To use the hospital generator pre-calculated benefit, the following requirements must be satisfied:

- The hospital must have an emergency department
- Hospital generator project represents a stand-alone solution. The subapplication must provide sufficient information to demonstrate technical feasibility and effectiveness of the mitigation solution (including a basis for the generator capacity related to critical services throughout the hospital as well as scope for a transfer switch, fuel storage, and other required components). If the generator is part of a larger project, the pre-calculated benefits from the generator portion cannot be combined or aggregated with the benefits from another portion of the project.
- Estimated benefits are based on $6.95 per BGSF in urban areas, including most suburban areas, and $12.62 in rural areas.[5]

With all requirements met, the community type the hospital resides in must be determined. This can be done using the 2010 U.S. Census[6] information as displayed in Figure 1 for areas within the contiguous United States. As stated in the previous section, the following areas are treated as rural communities in this methodology: Alaska, Hawaii, Puerto Rico, USVI, and other island territories.

Once the community type has been determined, the applicant/subapplicant simply needs to multiply the hospital's BGSF with the appropriate value based on the community type. The value calculated is the benefit associated with the installation of a generator to mitigate loss of function for the hospital.

[5] These benefits come from only critical functions, so the generator does not have to provide 100% loss of function (LOF) reduction to use these values.

[6] U.S. Census Bureau's Rural America Story Map retrieved from https://mtgis-portal.geo.census.gov/arcgis/apps/MapSeries/index.html?appid=49cd4bc9c8eb444ab51218c1d5001ef6

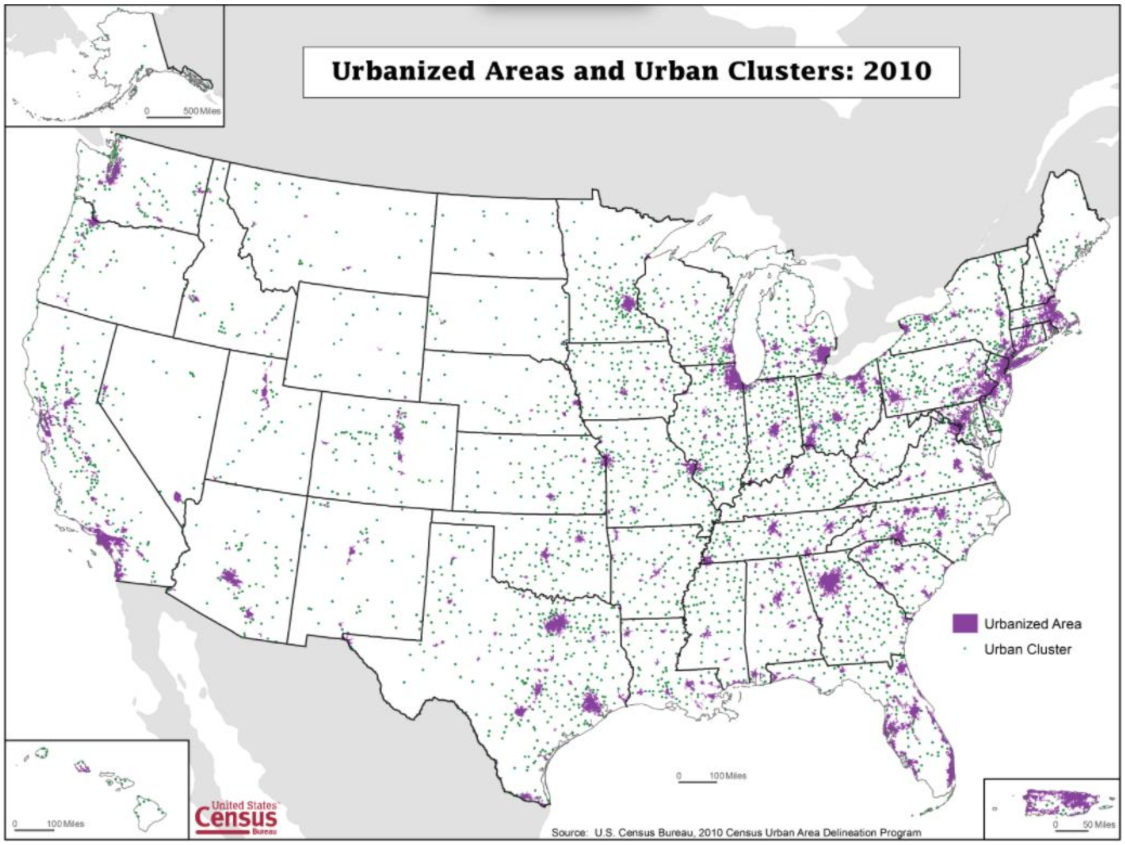

Figure 1. 2010 U.S. Census Data of Urbanized Areas and Urban Clusters

6. Conclusion

To satisfy the cost-effectiveness requirement for eligible HMA hospital emergency power projects, the hospital should estimate benefits based on $6.95 per BGSF in urban areas and $12.62 in rural areas. Since this is a pre-calculated benefit, applicants and subapplicants can still use the FEMA BCA Toolkit to complete a BCA if desired or if their projects do not meet the criteria for this pre-calculated benefit.