# COST-BENEFIT ANALYSIS FOR INVESTMENTS IN POWER GRID RESILIENCE – A GUIDE

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## Overview

The socioeconomic impacts of recent climate change have placed the environmental issue at the forefront of international debate. Climate change has changed the probability distribution associated to extreme weather events – the high impact and low frequency events, such as hurricanes, wildfires, snowstorms, floods, tornadoes and heat waves, have been more frequent and projections indicate greater intensity, duration and frequency over the coming decades. This global phenomenon threatens urban infrastructure and causes economic damage to companies operating on these sectors.

In the context of energy supply, these phenomena are already a reality and pose risks to the quality of supply (MOHAGHEGHI & DAELI, 2023). The challenges require responsive strategies capable of mitigating the effects and recovering quickly from the disasters that generated the interruption in supply - however the current regulatory framework lacks adequate instruments for recognizing investments in resilience. The situation is not different when we consider market design issues (LO PRETE & BLUMSACK, 2023).

Therefore, it is important to evaluate and develop reliability and resilience metrics that allow the regulator to understand how the prudent classification of investments in the electrical distribution network is affected by risks and climate events. This kind of research is essential to avoid misaligned incentives for investments in resilience, which could compromise the sustainability of the operation. A new challenge also arises for planning and operation management that demands the formulation of public policies that consider climate change on a large scale as an element of analysis, involving cost-benefit issues, risk modeling, attribution of responsibilities and coordination among different social actors. It is not just about physical investments; it involves the creation of specific protocols and policies.

In this paper we describe a specific framework for cost-benefit analysis of resilience investments, applicable to a generic electrical utility - a guide for the application of the basic principles of cost-benefit analysis in the evaluation of investments associated with the resilience of electricity grids. For this purpose, the paper is organized as follows: i) a literature review about infrastructure and power systems resilience; (ii) the step-by-step proposed for applying the methodology, inspired by the field of "Disaster Risk Management"; (iii) a hypothetical quantitative case study, that indicates which type of data is needed from a Distribution Company (DISCO) in order to implement the methodology at feeder's level; (iv) the presentation of an Enterprise Risk Management dashboard for resilience, capable to map and analyse critical risk for different areas covered by the utility.

The results, therefore, allow to the decision makers the choice of the best investments needed to increase the grid resilience – those that present a net social benefit greater than other alternatives, including maintaining the status quo.

## Methods

Cost-Benefit Analysis, Disaster Risk Management, Monte-Carlo Simulation, Market Design

## Results

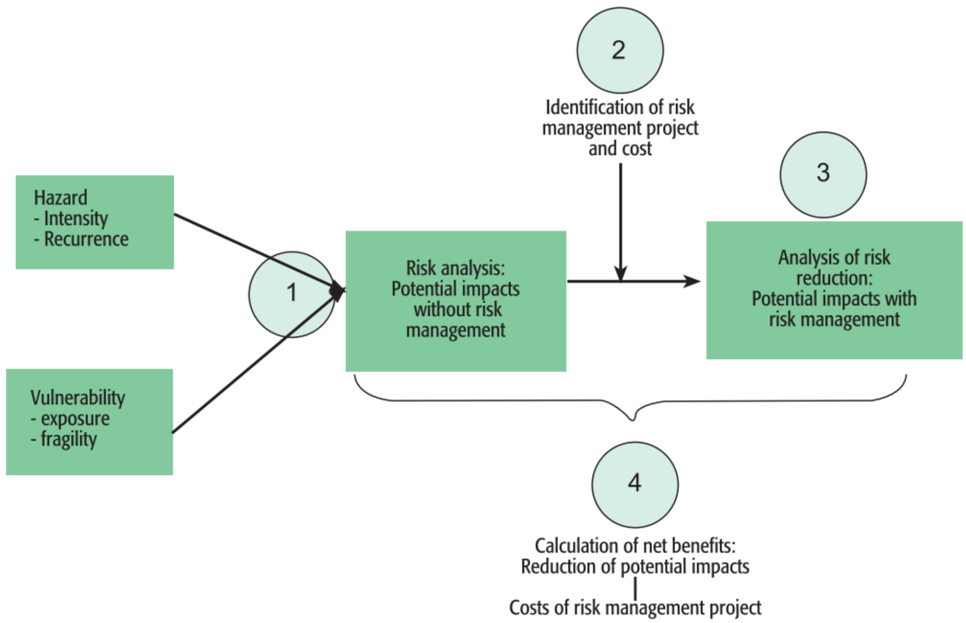
"Cost-Benefit Analysis" (CBA) is an economic tool used to directly compare the benefits and costs of a project or an activity. Investments in the resilience power grids are subject to: i) limited funding, and ii) the difficulty in defining the scope and/or the project/activity by itself. In this context, a CBA can assist decision makers in identifying which alternative achieves the greatest benefits per actual expenditure (i.e., which intervention is most cost-effective?). Apart from a traditional CBA analysis, it is important to take into account some steps related to risk modeling – in this specific case, knowledge from "Disaster Risk Management" (DRM) must be adapted to build a new framework for CBA in the context of investments on critical infrastructures resilience.

In the context of DRM – "Disaster Risk Management", two important issues deserve special attention when carrying out a CBA:

1. Risk assessment: The analysis should be done stochastically to account for the specific nature of risks associated with natural events and the impacts of subsequent disasters. This means that we must take into account the probability of occurrence of future disasters, related to extreme weather events that can/may significantly affect the electrical networks/infrastructures in a low resilience scenario.
2. Assessment of avoided risks: As the disaster risk is a 'negative' risk, the benefits stem from our capability/ability to avoid them. Therefore, investments in resilience can reduce the impacts of future losses, generating benefits from avoided risks related to disasters.

Therefore, from the DRM context, the process of a CBA for critical infrastructures resilience can be operationalized in four steps, as shown in Figure 1.

Figure 1- Framework for CBA in DRM.




Source: Mechler (2008).

**1. Risk analysis**: all the risks, in terms of potential and unmanaged impacts, must be assessed. This involves estimating and matching hazard(s), exposures and vulnerabilities.

**2. Identification of risk management measures and associated costs:** Based on the risk assessment, potential risk management alternatives for mitigation and their costs can be identified.

**3. Risk reduction analysis:** involves estimating of the benefits relate to risk reduction.

**4. Calculation of economic efficiency:** finally, economic efficiency is evaluated by comparing benefits and costs, for all the alternatives available to the decision maker.

This framework was implemented and adapted using as a pilot a Brazilian electric utility – a dashboard similar to those involve on Enterprise Risk Management (ERM) issues was created, capable to map the level of risk for different areas served by the firm. All the required data from a typical distribution company is also illustrated. Bellow we present some resilience-related questions that are possible to be answered by the platform developed:

- Which interventions should be prioritized? For example, should policy planners choose interventions that (i) protect the agricultural sector from climate change? (ii) focus on disaster risk reduction activities, or (iii) institutional transformations, such as changes in governance?
- Does the increased ability to avoid losses from a shock outweigh the associated costs? Or could the project be redesigned or modified so that more people benefit without increasing costs?
- Will families in the communities involved benefit from investments in risk reduction and will losses from shocks be avoided? Will other stakeholders (eg community groups, government) also benefit by creating incentives for them to participate in the project?
- Is there an alternative way to design or adapt the initiative, in a way that it can result in cost savings for the donor/investor?
- Will the project be financially sustainable after completion of the intervention and what are the risks to its long-term sustainability?

## Conclusions

In this article we present a hypothetical illustration about the roadmap to be followed in a Cost-Benefit analysis applied to investments in resilience of electrical networks and/or related to the prevention of natural disasters. Despite the simplifications adopted, it is a logical sequence that can be implemented in a systemic way, constituting a reference for the cost-benefit analysis of future projects associated with resilience. The results and simulations are presented through a specific ERM dashboard, capable to be used by other utilities or infrastructure firms, and also by other stakeholders, like governments and regulatory commissions.

## References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