Sandia National Laboratories

Energy Storage Benefit-Cost Analysis

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This research was funded by the US Department of Energy Office of Electricity Energy Storage Program under the guidance of Dr. Imre Gyuk.

SAND2021-1970PE

Benefit-Cost Analysis

- Benefit-Cost Analysis (BCA) is relatively simple in concept
- Benefit = sum of all benefits (monetizable and non-monetizable)
- Costs = sum of all costs
- Benefit/Cost ratio = $\frac{\sum Benefits}{\sum Costs}$
- B/C > 1.0 ⇔ GOOD
- B/C < 1.0 ⇔ BAD
- But there are a lot of details …

Benefit-Cost Analysis

An excellent reference for regulatory Benefit-Cost Analysis (BCA) is "Circular A-4, Regulatory Analysis" issued by the Office of Management and Budget 10/09/2003

Available online:

https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/

This Circular refines OMB's "best practices" document of 1996

Although the document is focused on good practices for Federal regulatory actions, it contains **a lot** of useful information

The Need for Analysis of Proposed Regulatory Action

This Circular is designed to assist analysts in the regulatory agencies by defining good regulatory analysis, called either "regulatory analysis" or "analysis" for brevity

Regulatory analysis is a tool regulatory agencies use to anticipate and evaluate the likely consequences of rules

It provides a formal way of organizing the evidence on the key effects, good and bad, of the various alternatives that should be considered in developing regulations

The motivation is to:

- learn if the benefits of an action are likely to justify the costs, or
- discover which of various possible alternatives would be the most cost-effective.

OMB Circular A-4, “Regulatory Analysis”, U.S. Office of Management and Budget, September 17, 2003

Ideal Case

All benefits and costs:

- Can be quantified
- Can be expressed in monetary units

Then, decision makers are left with a clear indication of the most efficient alternative: the alternative that generates the largest **net benefits** to society (net benefit = B-C)

NOTE: the decision criterion is the NET BENEFIT, not the B/C ratio

Why is the B/C ratio a bad decision criterion?

- It does not take into account the magnitude of B and C
- Scenario 1: B = \$100, C = \$1, B/C = 100, net benefit = \$99
- Scenario 2: B = \$100M, C = \$1M, B/C = 100, net benefit = \$99M

Unfortunately, you rarely come across the ideal case ☹

OMB Circular A-4, "Regulatory Analysis", U.S. Office of Management and Budget, September 17, 2003

The Real World

"It will not always be possible to express in monetary units all of the important benefits and costs."

This is an understatement – it is **rarely** possible to express in monetary units all of the important benefits and costs for energy storage deployments

For energy storage, the following situations are the "easy" B/C cases:

- Demand charge reduction, key assumptions: load profile and tariff structure going forward, energy storage cost
- Transmission and distribution upgrade deferral, key assumptions: load profile going forward, new equipment cost, energy storage cost
- Participating in a market, although there are market risks

OMB Circular A-4, "Regulatory Analysis", U.S. Office of Management and Budget, September 17, 2003

The Real World (continued)

For energy storage, the following situations are the "hard" B/C cases:

- Vertically integrated utilities – modeling and data requirements are high, often involving proprietary data
- Non-monetizable benefits are often difficult to assign a value
  - Carbon/greenhouse gas reduction
  - Improved resilience
  - Congestion relief
- Newer technologies (e.g., flow batteries) – it is often difficult to estimate the technology cost under different adoption scenarios
- For many storage technologies, it is difficult to estimate out year costs
  - Operation & maintenance (O/M) cost
  - Replacement cost
- Modeling human behavior
  - Adoption rates given various incentives/disincentives
  - Black swan events (e.g., Three Mile Island)
- 100% renewables/carbon free scenarios

OMB Circular A-4, "Regulatory Analysis", U.S. Office of Management and Budget, September 17, 2003

The Real World (continued)

OMB recommendation when it is difficult to assign a monetary value to all the important benefits and costs: “exercise professional judgment”

Good advice from the OMB: “If the non-quantified benefits and costs are likely to be important, you should carry out a "threshold" analysis to evaluate their significance.”

Threshold or "break-even" analysis answers the question, “How small could the value of the non-quantified benefits be (or how large would the value of the non-quantified costs need to be) before the rule would yield zero net benefits?”

Example:

Benefit = B1 + B2, B2 is not quantifiable

Cost = C

B1 + B2 – C > 0, B2 > C – B1

OMB Circular A-4, “Regulatory Analysis”, U.S. Office of Management and Budget, September 17, 2003

Key Elements of Regulatory Analysis

A good regulatory analysis should include the following three basic elements:

1. a statement of the need for the proposed action,

2. an examination of alternative approaches, and

3. an evaluation of the benefits and costs—quantitative and qualitative—of the proposed action and the main alternatives identified by the analysis

Why is this hard for energy storage?

- Energy storage is unique because of the ability to charge/discharge – this makes it difficult for an apples-to-apples comparison of alternative approaches
- It is often hard to quantify/monetize the benefits
- Even the costs are uncertain

OMB Circular A-4, "Regulatory Analysis", U.S. Office of Management and Budget, September 17, 2003

Key Elements of Good Regulatory Analysis

A good analysis is transparent. It should be possible for a qualified third party reading the report to see clearly how you arrived at your estimates and conclusions

For transparency's sake, you should state in your report what assumptions were used, such as the time horizon for the analysis and the discount rates applied to future benefits and costs

It is usually necessary to provide a sensitivity analysis to reveal whether, and to what extent, the results of the analysis are sensitive to plausible changes in the main assumptions and numeric inputs

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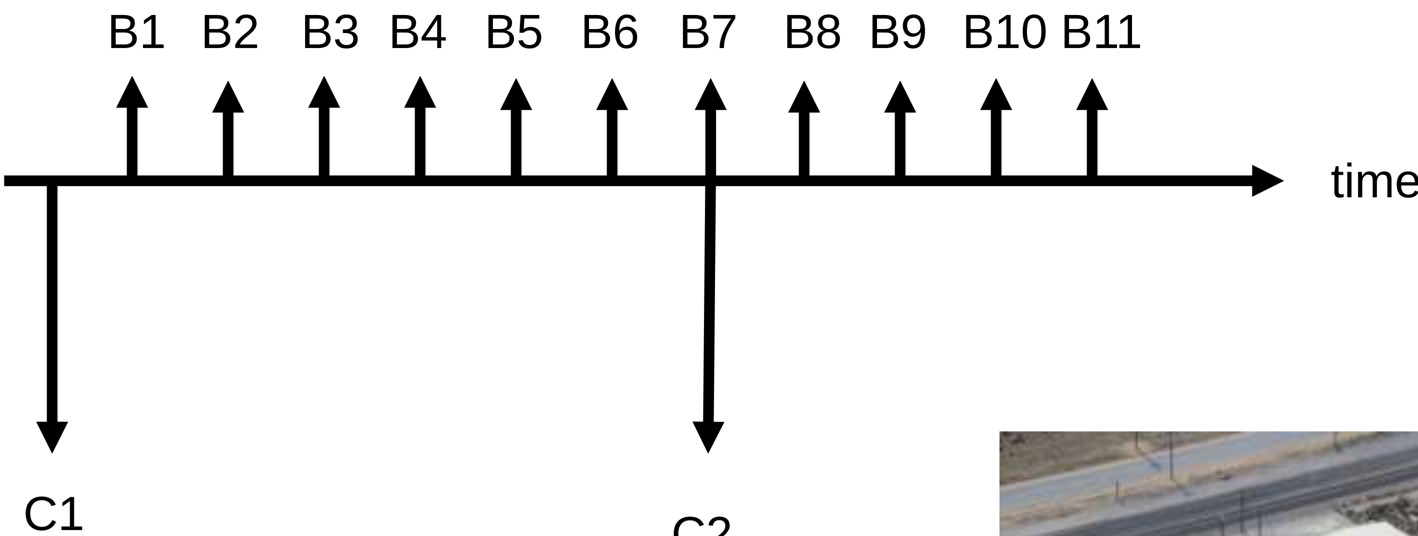
Concept of Present Value

"When, and only when, the estimated benefits and costs have been discounted, they can be added to determine the overall value of net benefits."



$$\text{Present Value (PV)} = \frac{Future\ Value\ (FV)}{(1+r)^t}$$

$$\text{PV} = \text{FV}e^{-rt}$$

$r = interest\ rate$

$t = period\ in\ years$

OMB Circular A-4, "Regulatory Analysis", U.S. Office of Management and Budget, September 17, 2003

Concept of Present Value

Rationale for discounting:

(a) Resources that are invested will normally earn a positive return, so current consumption is more expensive than future consumption, since you are giving up that expected return on investment when you consume today.

(b) Postponed benefits also have a cost because people generally prefer present to future consumption. They are said to have positive time preference.

(c) Also, if consumption continues to increase over time, as it has for most of U.S. history, an increment of consumption will be less valuable in the future than it would be today, because the principle of diminishing marginal utility implies that as total consumption increases, the value of a marginal unit of consumption tends to decline.

Benefits or costs that occur sooner are generally more valuable

OMB Circular A-4, "Regulatory Analysis", U.S. Office of Management and Budget, September 17, 2003

Concept of Present Value

What rate to use?

As a default position, OMB Circular A-94 states that a real discount rate of 7 percent should be used as a base-case for regulatory analysis. The 7 percent rate is an estimate of the average before-tax rate of return to private capital in the U.S. economy.

When regulation primarily and directly affects private consumption (e.g., through higher consumer prices for goods and services), a lower discount rate is appropriate: 3 percent

For regulatory analysis, you should provide estimates of net benefits using both 3 percent and 7 percent.

Circular A-94 also recommends using other discount rates to show the sensitivity of the estimates to the discount rate assumption.

OMB Circular A-4, "Regulatory Analysis", U.S. Office of Management and Budget, September 17, 2003

Games People Play with Discounting

The present value (PV) is always less than the future value (FV)

The higher the discount rate, the lower the present value of future benefits/costs

Discount Rate	30 year discount factor
2%	0.552
3%	0.412
5%	0.231
7%	0.131
10%	0.057

Pushing costs far into the future improves the net present benefit

Increasing the discount rate with large future costs improves the net present benefit

Decreasing the discount rate with large future benefits improves the net present benefit

OMB Circular A-4, "Regulatory Analysis", U.S. Office of Management and Budget, September 17, 2003

OMB Guidance on Difficult to Quantify Benefits and Costs

Present any relevant quantitative information along with a description of the unquantified effects, such as ecological gains, improvements in quality of life, and aesthetic beauty

Provide a discussion of the strengths and limitations of the qualitative information

This should include information on the key reason(s) why they cannot be quantified

For cases in which the unquantified benefits or costs affect a policy choice, you should provide a clear explanation of the rationale behind the choice

Use your "professional judgment" to highlight (e.g., with categories or rank ordering) the unquantified benefits and costs that you believe are most important

OMB Circular A-4, "Regulatory Analysis", U.S. Office of Management and Budget, September 17, 2003

The Difference between Costs (or Benefits) and Transfer Payments

Transfer payments are monetary payments from one group to another that do not affect total resources available to society

Examples of transfer payments include the following:

- Scarcity rents and monopoly profits
- Insurance payments
- Indirect taxes and subsidies

You should not include transfers in the estimates of the benefits and costs of a regulation.

Instead, address them in a separate discussion of the regulation's distributional effects.

OMB Circular A-4, “Regulatory Analysis”, U.S. Office of Management and Budget, September 17, 2003

Treatment of Uncertainty

Scenario Analysis: In some cases, the level of scientific uncertainty may be so large that you can only present discrete alternative scenarios without assessing the relative likelihood of each scenario quantitatively

For major rules involving annual economic effects of $1 billion or more … you should try to provide some estimate of the probability distribution of regulatory benefits and costs

COMMENT: estimating probability distributions for hard to quantify future costs/benefits is really hard!

Your analysis should report estimates in a way that reflects the degree of uncertainty and not create a false sense of precision

You should, if possible, use the 95 and 5 percent confidence bounds

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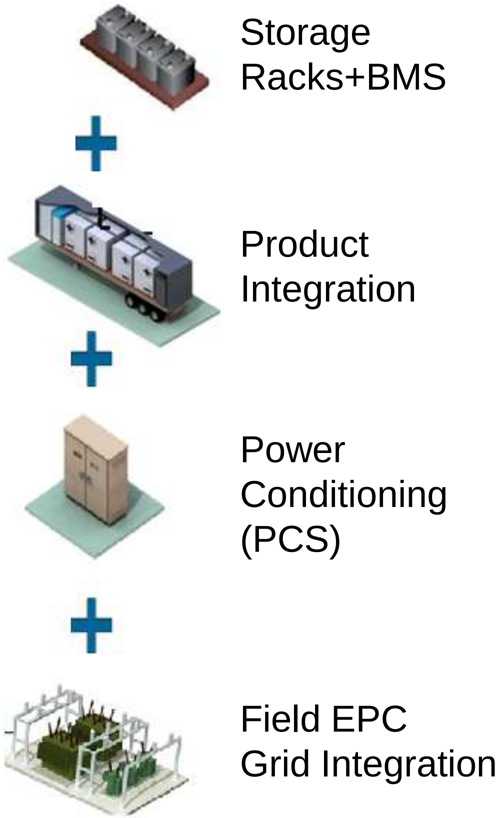
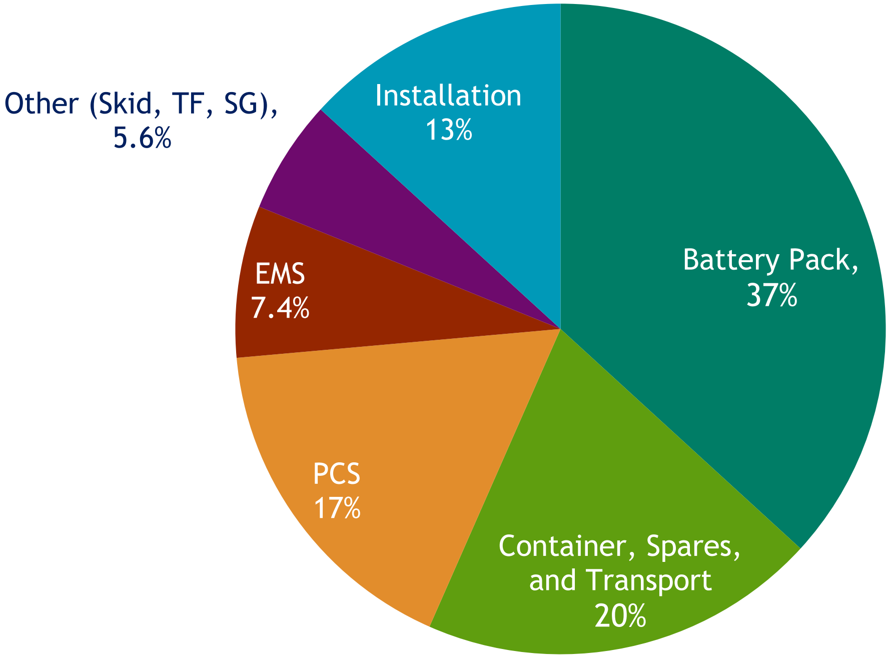
Estimating the Cost of Energy Storage

If someone makes statements regarding the cost of an energy storage system based solely on the power rating ($/MW) or energy rating ($/MWh) – they don' know what they are talking about





Cost Structure of Storage System ~ 2016

Simplest realistic price model = P ($/MW) + E ($/MWh)

Estimating the Cost of Energy Storage

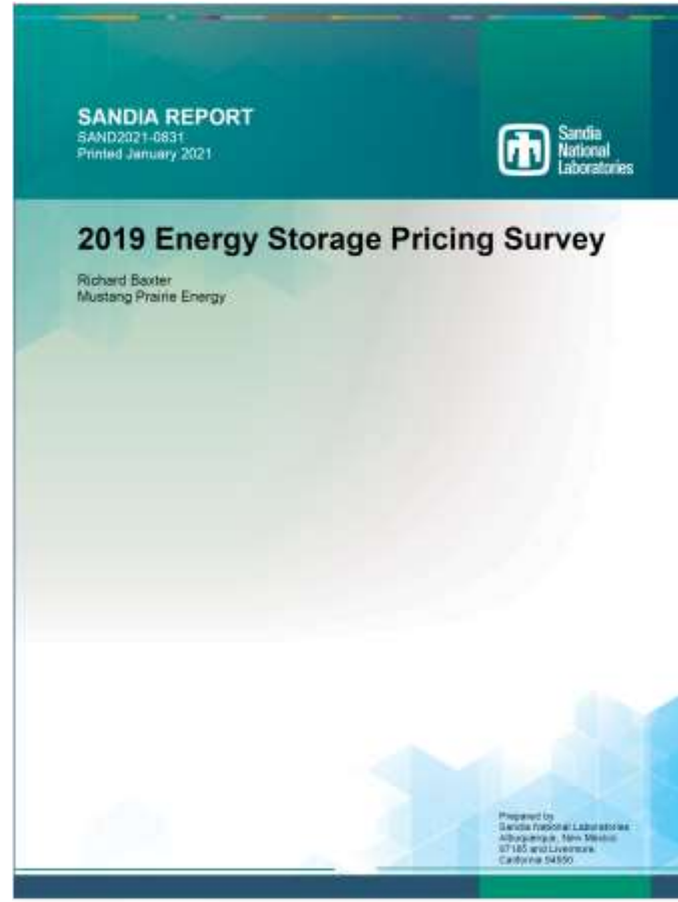
A good resource for current costs for different technologies:

Richard Baxter, “2019 Energy Storage Pricing Survey”, Sandia National Laboratories, SAND2021-0831, January 2021.

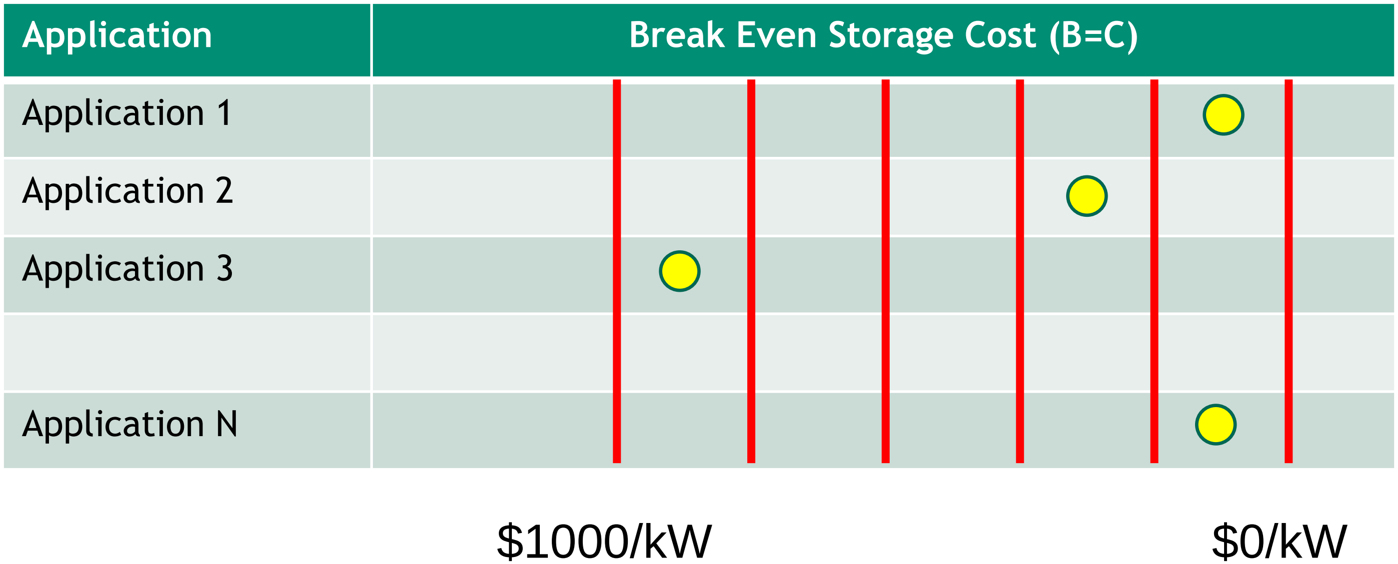
Available on:

www.sandia.gov/ESS

For estimating future costs, please keep in mind that the battery cost is only a fraction, usually less than 50%, of the total system cost



Interpreting Break Even Analysis



Question: what is the first takeaway from the chart above?

Observations:

- Application 1 only makes sense if storage is free. If this application is a high priority, it requires the most regulatory support
- Application 3 makes sense even with a high cost of storage, you should see a lot of examples of deployed systems

Summary and Conclusions

Benefit-Cost Analysis (BCA) is a powerful tool for regulatory analysis (if applied properly)

The net benefit to society is the proper criterion (not the highest B/C ratio)

Performing a BCA for energy storage can be hard

- Vertically integrated utility
- Quantifying non-monetizable benefits
- Estimating future costs

Properly treating uncertainty is an often-overlooked element of good regulatory analysis – there are many types of uncertainty associated with energy storage

OMB Circular A-4, Regulatory Analysis is an excellent reference

For more information, please visit the DOE Energy Storage program website:

www.sandia.gov/ess