

A Multiobjective "Analysis of Alternatives" Tool for Energy Investments at Fixed Site Installations

This research was funded by and performed in cooperation with the Logistics Management Institute (LMI)

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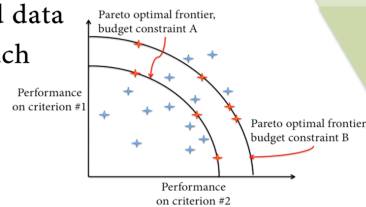
Iryna Payosova, M.S., Jonathan P. Deason, Ph.D., P.E.

Research Problem

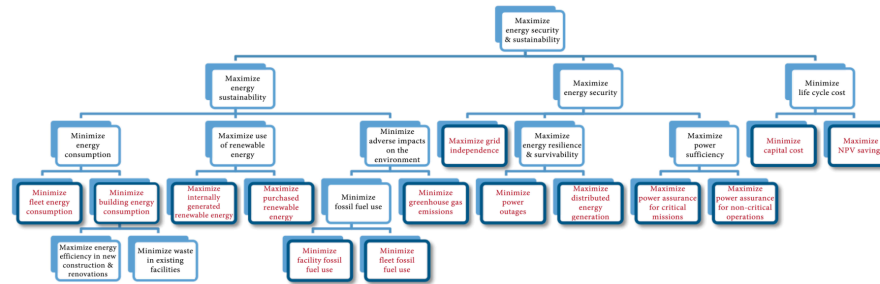
- Over 50 energy mandates facing Department of the Army (DA)
- Multiple conflicting and noncommensurable environmental and energy goals
- DA Net Zero Energy initiative
- Need to prioritize energy investment opportunities

Research Process

- Multiobjective multicriteria decision analysis
- Involvement of subject matter experts (SME) through the Delphi process
- *A priori* elicitations of objectives, criteria, and criteria weights from SME
- Optimization using normalized data
- *A priori* vs. *a posteriori* approach



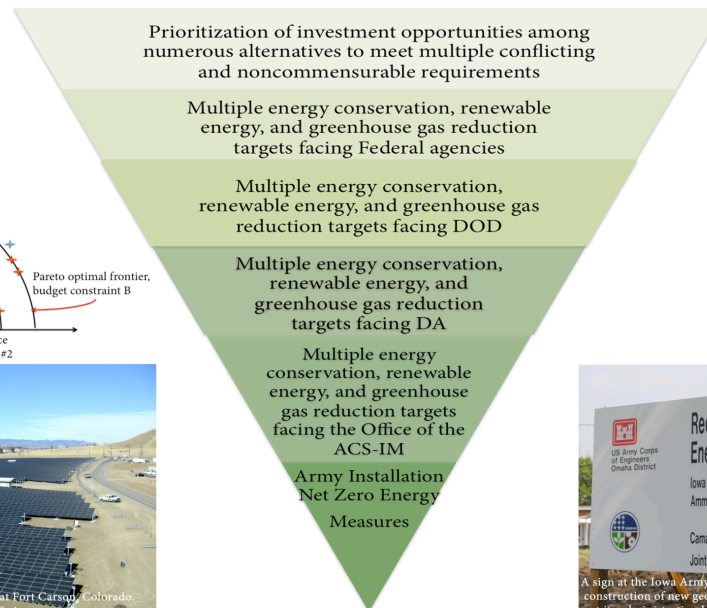
Objectives Hierarchy



Analysis of Alternatives Tool

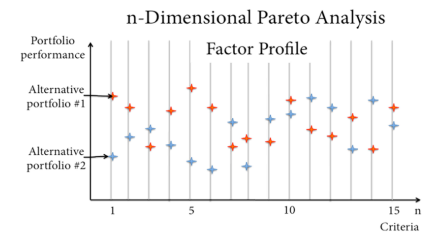
- Process of SME group idea generation and structuring is important
- Convergence of SME opinions
- Identification of preferred investment portfolios

Contextual Areas



Recommendations

- Implementation with key DA NZE officials
- Evolution of AoA tool
- Installation-level testing
- Development of a *posteriori* approach



A sign at the Iowa Army Ammunition Plant announces the construction of new geothermal and photovoltaic systems at its administration building. Photo Credit: U.S. Army



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Research question: Can a decision-support model be developed to help the United States Department of the Army (DA), Federal agencies and other large organizations prioritize energy investment opportunities in order to meet multiple conflicting and noncommensurable environmental and energy goals established by statutes, Executive Orders and other mandates?

Motivation for the research: All U.S. Federal government agencies presently are facing unprecedented challenges in the area of sustainable energy supplies due to a series of Presidential and Congressional mandates setting forth a number of extremely aggressive targets to guide a major transformation from dependence on fossil fuels to portfolios of renewable energy sources. DA has responded to this challenge via its Net Zero Energy initiative. To date, however, DA has not developed an analytical framework and set of relevant metrics to measure progress towards the net zero energy (NZE) goal. Instead, the Department is relying on a set of energy-related reporting requirements under the large set of mandates that currently apply to DA as means of assessing progress. This research is focused on developing an NZE assessment tool that can provide policy-relevant information to DA in a more useful manner than reliance on the extremely large and noncomparable data set available from current energy efficiency, renewable energy and greenhouse gas reduction reporting requirements. Moreover, such analytical framework and metrics will allow not only the assessment of current progress in existing programs and projects, but also the evaluation of energy investment alternatives.

Research method/approach: The analytical construct most appropriate for the net zero optimization problems involves a selection of tools from among those characterized as Multi-Criteria Decision Aiding (MCDA) methods. MCDA methods consist of a class of analytical procedures that can operationalize multiple incommensurable goals, objectives and criteria for problems. MCDA tools that rely on the input of subject matter experts (SMEs) can use either *a priori* or *a posteriori* elicitation approaches. In our research, we have primarily focused on *a priori* SME opinion elicitations. We also explored the pros and cons of *a priori* vs. *a posteriori* approaches. Our research consisted of the following steps: (1) Identification of energy-related mandates applicable to the Department of the Army, more than 50 total. (2) Enrollment of subject matter experts for our research from several organizational types: Department of Defense (DoD) and DA, other Federal organizations, private sector and investment companies, and energy-focused nonprofit organizations. The key criteria for selecting the SMEs were: level of expertise, comprehensive view of the NZE problem, and no direct stake for SME in the outcome of this research. (3) Conducting Phase I of the Delphi iterative process in which the SMEs reached consensus on an NZE objectives hierarchy. (4) Identification of a criteria set from this final objectives hierarchy. (5) Specification of energy investment alternatives (individual projects and portfolios) and of five different levels of budget constraints, using DoD documents, reports, and input from points of contact at DA. (6) Conducting Phase II of the Delphi process to elicit weights from the SMEs. (7) Optimization in order to identify preferred portfolios at each budget constraint level, using normalized project performance measures and the criteria weights collected via the Delphi process. This research was funded by the Logistics Management Institute (LMI) and performed in cooperation with the LMI and DA.

Research results: The primary result of this research is a multicriteria multiobjective NZE “analysis of alternatives (AoA)” tool. The proposed tool is an improvement to the current heuristic approach used by DA for making energy investment and budget allocation decisions. The importance of this research is in setting out the process for solving energy investment problems, and leading to a convergence of opinion among the SMEs. An additional result of this research is the identification of prospective benefits of the *a posteriori* MCDA approach, namely elimination of Pareto dominated alternatives.

Research conclusions: The research summarized herein was directed towards the development of a decision-aiding AoA tool to assist DA in identifying preferred energy investment portfolios at the national level while considering relevant criteria such as reduced energy consumption, increased internally generated renewable energy, potential for mission impairment, cost savings and environmental impacts. A key insight gained from this research is that a substantial convergence of opinion occurred within the SME group due to the learning processes inherent in implementation of the AoA tool described above. Proposed next steps include testing the tool at intermediate-command and installation levels.