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Advanced • Energy • Thinking

SENTECH WHITE PAPER

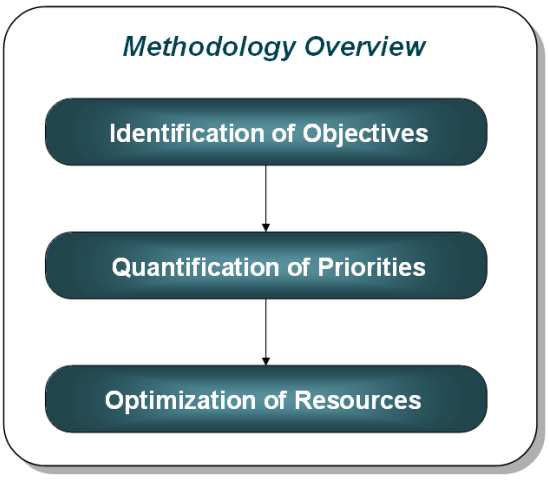
Using Multi-Criteria Decision Making and Linear Programming to Improve Federal Fleet Acquisition Strategies

Introduction

To reduce our dependence on foreign sources of energy, address climate change, and improve environmental quality, the U.S. government requires federal agencies to take a leadership role in purchasing alternative fuel vehicles (AFVs), using alternative fuel, and reducing petroleum consumption. These requirements, while serving as an important component of the overall U.S. energy strategy, create challenges for federal fleet managers, many of whom oversee large, geographically dispersed fleets that perform a diverse array of functions.

SENTECH, Inc. has developed and piloted a methodology to help agencies address these challenges. This methodology uses a structured approach to develop strategies for complying with federal fleet requirements while using agency resources as efficiently as possible. Specifically, the methodology employs multi-criteria decision making (MCDM) methods to identify and quantify agency priorities, in combination with a linear programming model to optimize the purchase of fleet vehicles based on these priorities. This paper presents an overview of this methodology and its capabilities.

Methodology Overview



In developing fleet strategies, agencies must strive to fulfill several different statutory requirements while also achieving agency-specific goals. They must also address issues including limited availability of AFVs, lack of alternative fuel infrastructure, and uncertain usage patterns. Further, it is often the case that several of their objectives conflict with one another. In a three-step process, SENTECH's methodology uses a systems approach that simultaneously addresses the many challenges that agencies face in developing fleet strategies. The agency's objectives are identified, quantified, prioritized, and then provided as inputs to a linear programming model that develops a recommended vehicle acquisition strategy based on the measured trade-offs that an agency is willing to make, and on specific characteristics of its fleet.

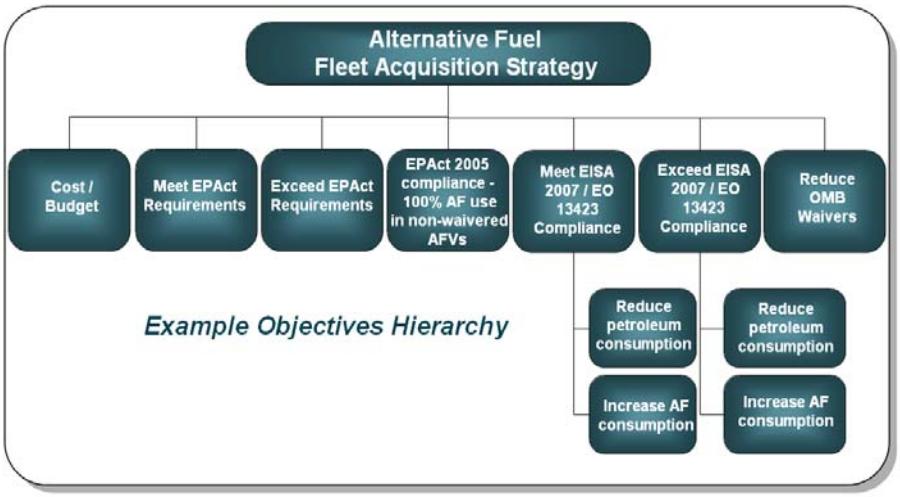
Inputs

There are three sets of inputs to the methodology – one for each primary step. The inputs to the first step are the set of objectives (statutory and otherwise) that the agency would like to achieve via its fleet management strategy. The fleet manager then answers a series of questions designed to elicit the priorities they place on each objective. For example, they may be asked to specify how much

compliance with one requirement they are willing to trade for a certain improvement in another area. These answers, along with directly assigned importance scores, are the inputs to the second step. In the third step, budgets and specific characteristics of the fleet are used along with the objectives and priorities determined in the previous steps as inputs to a linear model. The fleet characteristics used as inputs include vehicle models and garage locations, alternative fuel availability, expected usage statistics, and vehicle and fuel cost information.

Process

The first step in the methodology is to identify the agency's fleet management objectives. The intent of this step is two-fold: it defines the criteria that will be quantified in the next step for input into the model, and it also helps the fleet manager structure their thinking in terms of tradeoffs among the objectives. The figure below shows an example "objectives hierarchy" that was developed based on interviews with fleet managers from various agencies using a structured consensus-building technique. These objectives may differ depending on the individual agency, and the methodology is flexible to allow for this type of variance.



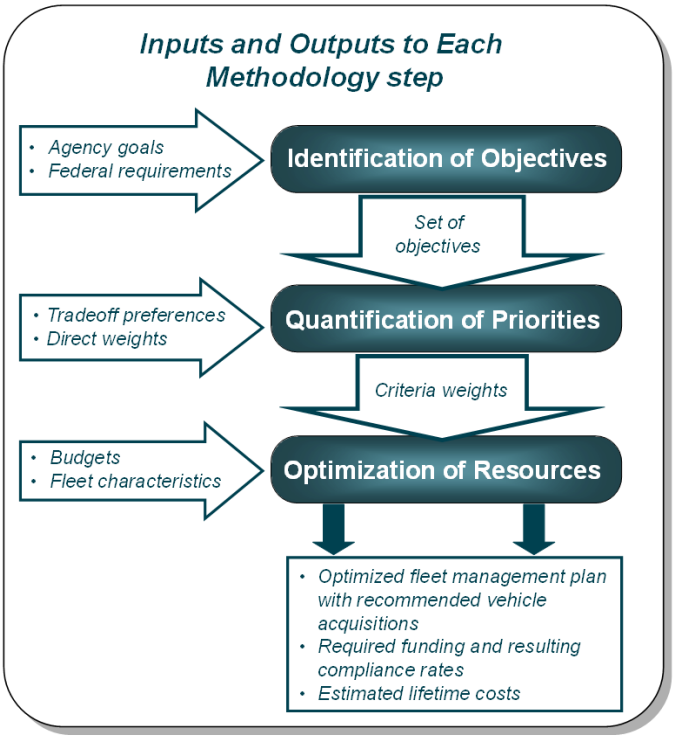
The second step quantifies the importance of each objective by assigning a relative weight. In the pilot study, weighting was accomplished with a two-pronged approach using both direct weighting and the Analytic Hierarchy Process (AHP). The results of both methods were assessed and compared in order to converge on a credible result. One of the most important aspects of this methodology is a focus on tradeoffs that must be made between the conflicting objectives that fleet managers face. The AHP method is used because it allows fleet managers to intuitively weigh the objectives against one another in a pair-wise fashion in order to quantify their preferences. Using direct weighting as a second method for comparison strengthens the quality of the result. By combining the use of direct weights and AHP, fleet managers are able to identify any inconsistencies between how they initially assign weights using the direct process and how they indirectly address tradeoffs using AHP.

In the optimization step, a linear program is used to assess the available resources and generate a recommended fleet acquisition strategy. The program is designed using a weighted objective

function – that is, a value for each objective is calculated, normalized, and multiplied by its relative weight generated in the previous step. The model's objective function seeks to maximize the sum of these quantities by varying the number and type of vehicles purchased at each location and identifying a global optimal solution. This is one of several approaches to resolving a multi-criteria problem with linear programming; other approaches could be used to suit the requirements of a particular agency as needed.

Outputs

The methodology produces several valuable outputs, any or all of which can be incorporated into an agency's fleet management strategy. The model outputs an optimized acquisition plan for a specified period of time, including the recommended number of vehicles to purchase at each location. The model also calculates the expected funding needed to carry out this strategy, as well as estimating the resulting compliance rates and lifetime costs. In addition, the first two steps produce useful information in the form of a clearly delineated set of objectives and quantification of the tradeoffs that the agency is willing to make.



The model can also be run backwards, allowing the agency to perform "what-if" scenario analyses. For example, agencies can estimate the compliance rates that would result from a certain vehicle purchase mix, assess impacts of moving vehicles from one location to another, or gauge the advantages gained by building additional fueling stations.

Conclusion

Agencies face difficult decisions as a result of the competing objectives they aim to achieve in fleet management. By using a structured multi-criteria decision making method via the process described in the paper, they can balance the achievement of these objectives according to their priorities. This methodology will not only improve and maintain an agency's rates of compliance with fleet requirements, but also assist them in demonstrating leadership by applying creative and innovative methods to the development of fleet strategies and helping lead the way to a more secure energy future. SENTECH can apply this process to assist agencies in developing a unique set of recommended actions tailored to their particular needs and constraints.

About SENTECH

Founded in 1989, SENTECH is a clean energy and energy efficiency consulting company whose mission is to work towards a healthier, cleaner, safer, and ultimately more prosperous world by advancing greater technical understanding and broader market adoption of clean energy and energy efficiency.

SENTECH provides high value services to its clients by drawing on its core values and the strengths of its cross-disciplinary staff, which includes engineers, market and policy analysts, communications and outreach specialists, management and program planning consultants, and event planners. SENTECH analyzes and implements effective, unbiased, and cost-effective strategic and technical solutions which address immediate and long-term client needs. SENTECH has both PES and MOBIS GSA schedules.

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