Focusing on the Market Potential in Segments

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Introduction

Over twenty years' of energy-efficiency programs have captured a significant amount of the cost-effective energy-efficiency potential. Recent national and international events have focused attention on the need for even greater energy-efficiency improvements. Is this possible? Are even greater improvements still available at reasonable returns on investment?[a] If so, to whom?

The Association of Energy services Professionals recently made these questions the topic of one of its Brown Bag Seminars, "Billions of KWh Saved: What's Still out There? Forecasting Energy Efficiency Potential." [1] A national study reported at this seminar put the amount at 605,000 GWh over the next 15 years, but noted that this included contributions from some technologies still in research. [2] Such technologies can be expected to carry a price premium when they reach the market, which raises doubts about their economic potential. Art Rosenfeld, in a presentation to the 2003 ACEEE Conference on Energy Efficiency as a Resource, foresaw an opportunity for additional savings in California from higher air conditioner efficiency standards (among other opportunities), which raises questions about the economic and political feasibility of such potential. [3] The Northwest Power and Conservation Council is looking at high-efficiency, higher-cost technologies as a source of future energy-efficiency potential in the Northwest. (Case study #3)

Certainly, a significant part of our energy-efficiency market potential lies in high-efficiency, higher-cost technologies that are not going to be perceived as cost effective for many consumers and businesses today. *Our ability to exploit this market potential, however, depends on our ability to identify the consumers and businesses for which these technologies are cost effective today, and developing marketing programs or standards to increase their penetration.*[b]

This paper reviews three different methodologies currently in use to estimate the market potential of these technologies. It focuses on methods to estimate potential in terms of economic feasibility and consumer interests.[c] The methods include some that are not in wide use, but which offer advantages that the more traditional approaches do not. All of the methods, however, share the following two steps:

1. Develop a test that defines which members of an end-user population should find the technology acceptable, e.g., a cost-effectiveness test, and then
2. Estimate the size of the population that passed the test, i.e., how many (and which) consumers have the characteristics needed to pass the test.

This paper is concerned principally with the second of these steps, estimating the size of the population that passes the test and is, therefore, likely to find the technology attractive.

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[a] In states that have largely ignored energy-efficiency and renewable-energy programs, common sense suggests that considerable market potential still exists. This paper addresses primarily the regions and states in which energy-efficiency programs have been offered since the early 1980s, and the remaining market potential depends largely on higher-efficiency technologies.

[b] The authors have argued in an earlier paper that marketing these technologies to early adopter segments will increase their market-driven sales and begin the process of bringing down their price through manufacturing economies of scale. [4]

[c] There are several types of market potential. We use the definitions used by the analysts whose work is reviewed.

The traditional approach to estimating the size of the population that passes a test for market potential involves segmenting the population, defining an *average member* of each segment, and then applying the test to determine if the average member passes it. Figure 1 illustrates how a planner might define a typical residential segment using this approach.

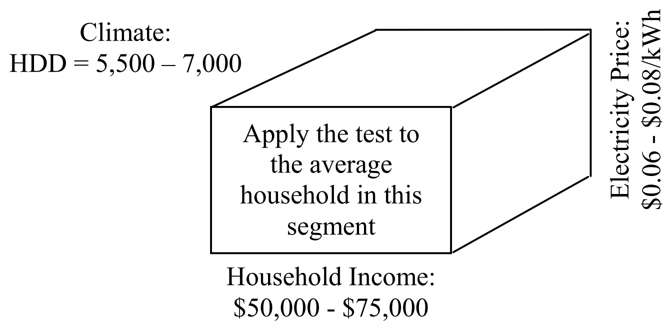

Figure 1: Typical Residential Segmentation Scheme for Estimating Market Potential

The planner has decided that climate, electricity price, and household income are the only variables that significantly affect whether a technology will be acceptable for residential households. An average household in the segment has been defined and will be the basis for the acceptability test. The average lies within the range of segmentation values shown. If the technology passes the test, it is judged attractive for the entire population in the segment. If it does not pass, it is not attractive for any member of the segment, and the entire segment will not be part of the market potential for the technology. The uncertainty associated with the test result is addressed by developing alternative scenarios, usually a better scenario and a worse scenario. This is done by selecting alternative input values for the test or the average segment consumer.

This approach using discrete segments and the average consumer has often led to failure on economic grounds for the higher-cost technologies. Failure has kept them out of estimates of market potential and out of the mainstream of energy-efficiency promotion. In an effort to increase the potential of these technologies, planners have turned to a variety of approaches.

The most common approach uses the traditional method described above but divides the market into very small segments in order to base the segment averages on narrower variable ranges. This approach has the advantage of guaranteeing that more of the population has had an opportunity to pass the test. (Case study #1)

Other planners have used a direct-marketing approach. They have selected the segments that industry knowledge or experience suggests will be most likely to be interested in the technology and direct-marketed them. They have then identified the characteristics of those who responded positively and used these to narrow their marketing target until the segments with the greatest interest in the technology are defined. (Case study #2)

Other planners have been confronted by demands from regulatory and political authority to provide explicit measures of uncertainty for their market-potential estimates. These planners have turned to probabilistic methods that explicitly estimate the uncertainty in the test outcomes. (Case study #3)

Case Study #1: Using Multiple Customer Characteristics to Define Many Segments: Cogeneration Systems — Bonneville Power Administration and TechPlan Assoc.

Situation

Under contract to the Bonneville Power Administration (BPA), TechPlan Associates performed a series of assessments of the potential for cogeneration in the commercial and industrial (C&I) sectors in the Pacific Northwest. BPA's wholesale power-marketing territory encompasses all of Idaho, Oregon, and Washington, the western portion of Montana, and small sections of California, Nevada, Utah, and Wyoming. BPA requested that the cogeneration assessments include all of Montana.

Method

TechPlan used its Cogeneration Regional Forecasting Model (CRFM) to calculate the economic potential of cogeneration installations. Assessments of cogeneration potential are complex undertakings, in part because of the large number of parameters that must be considered, and in part because cogeneration is not a single technology but rather is a *family of technologies*. The analyst has no way of knowing which specific technology, and what system size (i.e., generating capacity), are optimum for a given facility. The only solution is to investigate a large number of options ("candidate systems") and see which shows the best economic results.

Market Segmentation and Subdivision. The market for cogeneration installations was defined in terms of C&I facilities that can "host" a cogeneration system. The host facility uses the thermal energy "product" of the system and may use all, some, or none of the electricity "product."[d]

The host facilities were segmented in terms of three dimensions: type, size, and location:

- *Representative Facility Types:* 25 categories (15 in the commercial and 10 in the industrial sector), each defined by a set of loads (one electrical and up to three thermal)
- *Size Categories:* 4 categories (Electrical and thermal loads were calculated by multiplying the Representative Facility Type's loads by a set of "size coefficients.")
- *Geographic Sub-Regions:* 23 categories (ten groupings of electric utility service areas, where the groupings were defined in terms of similar retail price, and three climate zones).

This segmentation subdivision scheme means that cogeneration opportunities were investigated in each of 2,300 "cells" (23 geographic locations, each potentially containing 100 facility-type and size combinations, where each combination has a specified population).[e]

Candidate Cogeneration Systems. The economic feasibility of 22 different *Cogeneration System Types* were considered. Each system type was defined in terms of: (a) prime mover and/or configuration (e.g., reciprocating engine, gas turbine, steam turbine, combined cycle), and (b) a range of generating capacities. Some System Type configurations had only a single thermal output stream, and some had two thermal output streams. (Each stream is defined in terms of two parameters, a characteristic temperature and a "thermal-to-electric ratio.") For example, there were five System Types with reciprocating engines as their prime mover, spanning an overall capacity range of 30 kW to 2,000 kW,

[d] When the electrical capacity rating of the system is smaller than 500 kW, it was assumed that the host uses all electricity generated by the system. In the case of larger systems, the CRFM considered the option of selling some or all of the electrical generation to the grid.

[e] Some cells had a zero population.

with a single thermal output stream. There were also four System Types with reciprocating engines as their prime mover, spanning an overall capacity range of 60 kW to 2,000 kW, with two thermal output streams, one of which was chilled water obtained via an absorption chiller that is powered by some of the thermal output. The characteristic temperature of the "heating" output stream was a function of prime mover and rated electrical capacity.

Capital costs ($/kW) were defined for the low and high endpoints of the ranges, reflecting economies-of-scale (as generating capacity increases, $/kW decreases).[f] For each System Type, an input fuel, average heat rate, average thermal-to electric ratio, average operating and maintenance cost, and input fuel, were also defined.

Electricity and Fuel Prices. Ten sets of *retail electricity prices* were represented in the model. Each set contained a specific price that was applicable to one of the four host-facility size categories in one or more sub-regions. In the case of natural gas and fuel oil prices, the same price structure was used in all geographic sub-regions, but the price magnitude was an inverse function of the amount of energy purchased by the host facility each year (with a floor price and a ceiling price), to reflect rate-structure effects. In the case of wood and waste materials, it was known that these materials were regularly bought and sold in the region, but only very limited price data were available; therefore, a single price point was used for all sub-regions and size categories.

Two *Escalation-Rate Scenarios* were considered in the study: "Base" and "High", which respectively correspond to the "Medium" and "High" forecast scenarios prepared by BPA and the Northwest Power Planning Council. Both electricity prices and fuel prices were assumed to experience escalation and inflation over time. Cogeneration operating and maintenance costs increased each year in accordance with the inflation rate.

Electricity sell-back price (ESB) was varied in 0.5 cent/kWh increments between 2.0 and 6.0 cents/kWh to create alternative scenarios of potential for the Base case and High case.

Economic Tests. Three different host facility *economic decision criteria* were represented in the analysis model. First, there was the requirement that the magnitude of the discounted cost savings exceed a specified minimum value (e.g., 10%). If the savings were less than the minimum, the decision-maker would not be willing to spend the time needed to plan and implement a cogeneration project.

The second criterion was that of a "hurdle rate," the minimum ("threshold") economic rate-of-return required by decision-makers. Hurdle rate is expressed in terms of an after-tax internal-rate-of-return (IRR) value, ranging from 12% to 25%, depending on the type and size of the host facility. A hurdle-rate value is specified for each of the 100 facility type and size category combinations.

The third criterion is based on the magnitude of IRR. As noted above, it serves to: (a) rank the candidate systems that satisfy the first-two criteria, and (b) assign the magnitude of the installation probability. The latter is represented by a curve that varied from 5% for IRR = 12% to 95% for IRR = 40% or greater.

What the CRFM Program Does. Each of the 2,300 cells was serially considered. For each cell that has a nonzero population, the initial set of calculations produce: (a) annual electricity and thermal usage data, and (b) "first-year" energy-cost values for the "No Cogeneration" base case. The energy cost

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[f] When a generating capacity was selected within the range defined for a system type, the capital cost was interpolated.

figures are then escalated over the 20-year study period and the net present value (NPV) of energy costs calculated. The program then sequentially selects the first of several candidate cogeneration systems to investigate. The candidate will be an appropriate system type with a specific capacity rating (typically, three to five capacity ratings are investigated for each system type). For each candidate, calculations are performed for the 12 time periods to calculate: (a) cogeneration system performance, (b) the amount of the host facility's electricity and thermal energy needs provided by the System, (c) electricity and fuel that are purchased, and (d) cogeneration system owning and operating costs. System performance is then analyzed to screen out system types that do not satisfy the PURPA qualifying-facility criteria. When the ESB is greater than the retail electricity price, the calculations are repeated for the situation where all electricity generated is sold to the grid. The results for the situation that produces the largest first-year net savings are kept and escalated over the study period. The NPV of savings are calculated.

Next, the first economic criterion (minimum discounted savings) is investigated. If this criterion is satisfied, the IRR is calculated and the second economic criterion (hurdle rate) is investigated. If this criterion is satisfied, the cogeneration output and IRR are stored, and the next candidate system is investigated using the same procedures. When all the candidate systems have been investigated, the stored results are screened. If there are more than three, the ones with the highest IRR are selected, weighting factors and the probability factor are applied, and the economic potential for the cell is calculated by also multiplying by the population of host facilities associated with the cell. Similar calculations are performed if there are fewer than three but at least one eligible cogeneration system(s). The methodology produces the weighted probability that members of each segment will install cogeneration systems.

Results

Table 1 presents the results from one set of calculations. Market Potential is shown as a function of ESB. If these results were plotted, they would be the cogeneration resource supply curve, which could be compared with the resource magnitude provided by other technologies.

Table 1: Overall Market Potential (aMW[f])

First-Year ESB Price (Cents/kWh)	Scenario	
	"Base"	"High"
2.0	186	274
2.5	255	401
3.0	410	673
3.5	824	1,800
4.0	1,560	5,100
4.5	4,600	8,670
5.0	7,510	13,800
5.5	12,600	21,700
6.0	20,000	29,600

In addition to producing the market potential results, CRFM also identifies the market segments with a high probability of installing cogeneration. Program designers can then examine the characteristics of

[f] Average megawatt (aMW) is a unit of electrical energy that is commonly used in the Pacific Northwest. 1.0 aMW = 8,760 MWh (1.0 MW times 8,760 hours).

these segments to develop information by which effective marketing programs can be created. CRFM also disaggregates the market potential results in terms of system type and size (capacity rating), as well as market segment where the systems are installed. This will permit refinement of the marketing program to promote specific types of cogeneration systems within specific market sub-segments (i.e., specific facility types and sizes, in specific geographic locations).

Advantages and Disadvantages of Method

Advantages:

- The large number of cells provides confidence that the population is well represented and very few facilities that would find cogeneration economically attractive are excluded due to use of the segment average.

Disadvantages:

- May require significant effort to design and test software to calculate and keep track of the engineering and economic results.

Case Study #2: Using Responses to Direct Marketing to Segment: Customer-Sited Clean Energy Systems — Public Service Electric & Gas[g]

Situation

The New Jersey Clean Energy Program is a statewide program initiated in April 2001 that seeks to transform the market for customer-installed, grid-connected power-generating systems using photovoltaic, wind, biomass energy sources, or fuel cells installed by investor-owned utility customers. Because the market prior to that time was virtually non-existent, it could be said that the purpose of the program is to create conditions that will lead to a viable market for these technologies in New Jersey. To achieve this end, the program: (a) sponsors public-education seminars and conducts other awareness-building activities e.g., advertising in newspapers and other publications, sponsoring and participating in trade fairs, speaking at business association meetings; (b) sponsors training programs for new photovoltaic system installers and local code-enforcement officials; and (c) provides rebates to purchasers, to make the systems more affordable. The New Jersey Board of Public Utilities (NJBPU) has been a strong proponent of the program, and has required the state's electric utilities to implement net metering for systems with rated capacities up to 100 kW, and to also develop standardized and simplified electrical interconnection requirements.

The program is funded via a portion of a public-benefits surcharge applied to the monthly bills of all retail customers of the state's seven electric and gas utilities that are subject to NJBPU regulation. Until this year, the program was administered by these seven utilities on an interim basis. By the end of 2002, 1,142 kW of generating capacity had been installed via the program, which was more than double the 500-kW goal. Applications for an additional 4,247 kW of capacity had been approved and were awaiting hardware delivery and installation, or final inspections and approvals. [5] As of mid-2003, the NJBPU assumed the role of program administrator.

[g] The authors are grateful to Ms. Elaine Bryant, Program Manager for the Clean Energy Program at Public Service Electric & Gas, for the assistance provided in preparing this case study. The authors are solely responsible for any errors, however.

Method and Results

Although the same program was offered by the seven utilities, and the application form, program brochure, training activities, and some promotional activities were done jointly, each utility performed additional marketing activities of their own choosing. Shortly after the program began, Public Service Electric and Gas (PSE&G, the largest utility in the state) decided to initiate a series of mass mailings to residential customers. One option was to mail to each of the 2.0 million customers in this sector. However, a survey conducted to establish background information disclosed that customers who had a strong interest in environmental protection were most likely to participate. [6] Therefore, the PSE&G decided to limit the mailings to residential customers who met this criterion.

A 200,000-name mailing list of persons who lived in postal ZIP codes within the PSE&G service territory and had made a financial contribution to an environmental organization within the past two years, was purchased from a commercial mailing-list vendor. Mailings were made in October and November of 2001 to the full list. The 10,480 persons who responded were sent additional program information and were notified when a public seminar was to be held in a location near the area where they lived. Additional mailings were made in February and April of 2002 to a randomly selected subset of 60,000 names extracted from the initial list. Table 2 shows the response rate to these four mailings.

Table 2: First Four Mailings

Mailing	Number Mailed	Number of Responders	Percentage of Responders	Cumulative Percentage of Responders
October 2001	200 K	6,007	3.0 %	3.0 %
November 2001	200 K	4,473	2.2 %	5.2 %
February 2002	60 K	909	1.5 %	6.7 %
April 2002	60 K	600	1.0 %	7.7 %
Total		11,989		

PSE&G then analyzed three other items of information about the 11,989 responders to the four mailings that was available in the utility's records: (a) annual electricity usage, (b) prior participation in some utility activity or program (e.g., purchase of an appliance service contract), and (c) the respondents' *MicroVision* segment.[g] The results showed a high concentration of respondents in twelve *MicroVison* segments that had response rates of four percent or greater. In addition, there was strong correlation between response and electricity usage, with response rising as usage increased. Prior participation in other activities or programs intensified the response from both the *MicroVison* segments and high electricity users. The results of the responder analysis showed that the customers most likely to participate in the program had the following characteristics:

- Used higher than average electricity
- Multiple utility relationships
- Lived in a suburban location
- Had a high income
- One or both heads of household had post-high school education

[g] PSE&G had previously subscribed to Claritas' *MicroVision* segmentation system and had incorporated the system's descriptors into its CIS database for each customer.

- One or both heads of household were “white-collar professionals”
- The ages of one or both heads of household were in the 40-59 range
- The household had children over age 10.

The database of all PSE&G residential electric customers was then screened to select 60,000 names who: (a) had high annual electricity usage, (b) participated in some PSE&G activity or program, and (c) had not received an earlier program mailing. Mailings were made in May and June of 2002 to the new list. The response rates from these mailings were 2.2 % and 1.8 %, respectively.

Advantages and Disadvantages of Method

Advantages:

- Identifies customers who have taken the time to show an interest in the technology and allow them to be characterized for further marketing purposes.
- For relatively high-cost and unfamiliar technologies like customer-sited clean-energy systems, it may be more effective to identify early adopters with an interest than to estimate market potential on economic criteria.

Disadvantages:

- Relatively high cost of direct-mail marketing cannot estimate whether respondent will have an economic motivation to actually install the technology.

Case Study #3: Using Monte Carlo Analysis to Develop Probabilities of Cost Effectiveness by Segment: High-Efficiency, Higher-Cost Technologies— Northwest Power and Conservation Council[h]

Situation

The Northwest Power and Conservation Council (Council, formerly known as the Northwest Power Planning Council) was established in 1980 by Federal legislation (Northwest Power Act) to develop and maintain a regional power plan and a fish and wildlife program that balances the Pacific Northwest’s energy and environmental needs. [7] The Council’s mandate covers the Columbia River drainage basin and includes parts of the states of Washington, Oregon, Idaho, Montana, and Wyoming. Every five years the Council develops a revised energy plan for the region that incorporates as much energy conservation as is economically feasible. It is currently developing the fifth such plan and is using Monte Carlo analysis to estimate the economic market potential for some of the higher-cost energy efficient and renewable-energy technologies currently on the market.

This is the Council’s first use of Monte Carlo analysis to estimate the economic potential of conservation measures. It turned to Monte Carlo for the Fifth Power Plan because (a) higher model-code standards in the Northwest have pushed additional conservation into the realm of higher-cost technologies and raised uncertainties about their market potential, (b) political authorities want better knowledge about the number of consumers that can benefit from higher standards and programs for

[h] The authors are grateful to Tom Eckman, Manager, Conservation Resources, Northwest Power Planning Council, for the assistance provided in preparing this case study. The authors are solely responsible for any errors, however.

these technologies, and (c) computing technology, software, and Internet access have made Monte Carlo analysis feasible under conditions of limited resources.

Cost-effective, in the Northwest, means the net present value (NPV) of the energy-efficiency technology, computed with system as well as consumer costs and benefits, is no more than 110% of the incremental cost of an alternative supply-side resource that provides equivalent energy and power.[i] The Council traditionally used a method similar to that described in the first case study in this paper to estimate market potential for energy efficient and renewable energy technologies. It divided the market into small segments and used an average consumer (or business type) for individual segments to estimate the cost effectiveness for each technology.

However, the Council has always recognized that when a technology fails the economic test based on an average consumer, it does not mean that every consumer in the segment would fail the test. The technology likely would be cost-effective for *some* consumers in the segment. The Council turned to Monte Carlo analysis to identify and quantify the market potential represented by those consumers. Among the technologies to which it has applied Monte Carlo analysis are heat pump water heaters, compact fluorescent lights, variable speed drive motors, solar water heaters, higher building shell thermal efficiencies, and higher-efficiency heat pumps and fluorescent lighting.[j]

Method

Monte Carlo studies estimate the probability distribution for an outcome of interest given the probability distribution of one or more of the inputs needed to forecast to that outcome. Historically, one problem with applying Monte Carlo analyses to estimate market potential has been the cost of obtaining credible probability distributions for these inputs. Information available on the Internet now creates opportunities to develop these distributions from historical data and other sources.

To apply the method, the Council developed algorithms for the NPV of the energy-conserving technologies and alternative system resources. These algorithms consisted of engineering and financial algorithms. The engineering algorithms are those common to most energy-savings estimates. They use the estimated energy uses of the efficient technology and a baseline technology under specified assumptions to calculate the annual energy savings and hourly power savings of the energy-efficient technology.

Like the engineering algorithms, the financial algorithms that calculate the NPV of the installed technology are algorithms widely used for this purpose. The economic cost-effectiveness test compares the NPV for the system of the technology with the system NPV of the avoided alternative supply-side resource.

To this point, the Council's method for calculating the NPV for a technology is similar to the method used in the first case study, i.e., the algorithms are used to generate point estimates of cost effectiveness based on assumptions about the technology and its user.

The difference in the two methods exists in the way the methods address the uncertainty in the economic market potential for the range of consumer variation within a segment. The traditional methods

[i] Northwest Power Act, 839a(4)(A).

[j] Increased code levels in the Northwest have reduced the savings available from some of the higher-efficiency (and higher-cost) traditional technologies such as high R-value insulation. As a result, they are less likely to pass a cost-effectiveness test based on the average consumer.

exemplified by the first case study develop upper and lower point estimates by varying one of the input variables. A Monte Carlo analysis replaces one or more input variables with their probability distributions in the segment. For example, using a typical engineering algorithm for energy savings per household for an efficient clothes washer, the variables for loads per occupant and occupants per household, which would normally be estimated averages, can be replaced in a Monte Carlo analysis with probability distributions:

$$\text{Energy Savings/yr} = (\text{watts/load}_{\text{base}} - \text{watts/load}_{\text{efficient}}) \times \underbrace{(\text{loads/yr-occupant})}_{\text{Replace with probability distribution}} \times \underbrace{(\text{occupants/household})}_{\text{Replace with probability distribution}}$$

Then, through multiple iterations of the joint distributions of these variables, the method calculates the probability distribution for energy savings for an efficient clothes washer. If the input distributions consist of discrete values, the output probability distribution will be in the form of a histogram. The analysis can be performed for any market for which the distributions are available. Figure 2 illustrates a possible output of such a Monte Carlo analysis of energy savings.

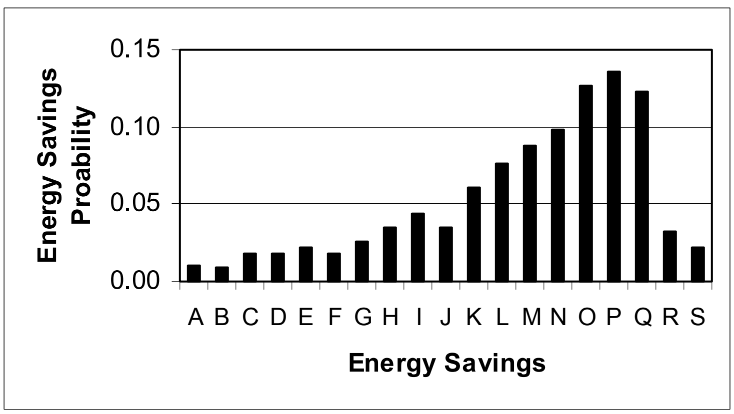

Figure 2: Probability Distribution of Energy Savings from Monte Carlo Analysis

The energy-savings distribution is then input to the financial algorithms along with the distributions used for the financial inputs. The output is a probability distribution of the NPVs for each combination of inputs. The analyst can weight each NPV with its probability to develop a weighted average probability that the efficient clothes washer is cost effective for all households in the population. Alternatively, the distribution allows the analyst to calculate the probability that the NPV will be above or below a specified NPV, e.g., equal to or less than 110% of the NPV of an alternative supply-side resource. Because the histogram represents the number of households with each NPV, this probability also provides decision-makers with a probability estimate of the number of consumers in the population for which the high-efficiency clothes washer passes the region's economic test criteria.

Monte Carlo analysis allows the analyst to identify the characteristics of consumers/businesses with high probabilities of cost-effectiveness. These characteristics create segments for marketing purposes.

The amount of calculational effort required for a Monte Carlo analysis can be large, but even with a large number (e.g., a dozen) input-variable distributions, contemporary personal-computer (PC) speeds allow thousands of iterations to be performed in minutes. The Council estimates that none of its analyses required more than two minutes.

Commercially available, user-friendly software programs facilitate rapid computation of Monte Carlo analyses. The Council used Decisioneering, Inc.'s Crystal Ball® software. [8] This software enables an analyst with an elementary understanding of probability theory (but a good understanding of engineering and financial analysis) to run Monte Carlo analyses on a personal computer and output the results into a Microsoft Excel spreadsheet and chart.

The analysis element that differentiates a Monte Carlo analysis from the more traditional forms of estimating market potential also creates a requirement that the analyst have probability distributions for the key input variables. The minimum number of distributions used by the Council to analyze single technology was three (used for the heat pump hot water heater analysis). The maximum number was twelve (used for new-home construction standards). Table 3 shows some of the input variables for which the Council developed probability distributions.

Table 3: Examples of Variables for Which the Council Developed Probability Distributions

Engineering Variables	Financial Variables
Building size in square feet	Mortgage rates
Duty cycle (annual hours of use of the technology)	Household income
Number of persons in household	Income tax rates
Existing levels of insulation	Initial and operating costs of the technology
Population by climate	Wholesale and retail energy costs

With high computer speeds and user-friendly software, the principal challenge of the Monte Carlo method is developing these distributions. The Council used a variety of methods for this purpose. For some variables, it used standard probability distributions, e.g., normal, triangular, trapezoidal, that are available with the Crystal Ball software. These distributions require that the analyst specify a mean, standard deviation, and maximum and minimum values. For other variables, e.g., mortgage rates, it used thirty years of historical data to develop the shape of the distribution, and applied that to a forecast of future rates (which was treated as the mean).

Results

At the time this paper was written, the Council's use of Monte Carlo analysis to develop the economic potential of the higher-cost technologies was a work in progress. Selected results were expected to be available for the Conference presentation.

Advantages and Disadvantages of the Method

Advantages:

- Usually costs less than methods requiring a survey to estimate the size of populations for which technology has potential.
- Provides a probability-weighted estimate of the size of the market potential. This helps regulatory and other authorities understand the uncertainty in the estimate of market potential as well as the comparative size of the population that will not find the technology cost-effective.

Disadvantages:

- Requires large quantities of secondary data to estimate the probability distributions. Assumed distributions may be used in the absence of secondary data, but they may not be accurate.
- Requires a basic understanding of probability theory in order to set up the Monte Carlo analysis and report it.

Summary

The need for greater levels of energy efficiency has created a corresponding need for estimates of the market potential available for higher-cost and lesser-know technologies. Table 4 summarizes the advantages and disadvantages of the three methods reviewed by this paper that have been used to estimate such potential.

Table 4: Advantages and Disadvantages of the Methods Reviewed

Method	Advantages	Disadvantages
Traditional Method Using Average Within Segment (Case Study #1)	• Relatively inexpensive, but expense increases as more segments are used. • Large numbers of segments provide confidence that the results actually represent the population.	• Requires large number of segments to ensure all of the potential is being estimated. • May require significant effort to design and test the software to calculate and track the potentials for each segment.
Market First, Define Segments with Potential from Responses (Case Study #2)	• Identifies consumers/businesses who are more likely to install the technology because they have taken time to respond to a direct mail promotion. • For relatively high-cost and unfamiliar technologies like customer-sited photovoltaic systems, this approach may be more effective for identifying early adopters than to estimate market potential on economic criteria.	• Relatively high cost of direct-mail marketing campaign. • Cannot estimate whether a customer will have an economic motivation to install the technology.
Monte Carlo Analysis (Case Study #3)	• Lower cost than survey-based methods. • Incorporates uncertainty explicitly; gives decision-makers a probability estimate of the size of the market potential. • Probability estimates are useful for estimating the size of the population that may be adversely affected by higher standards and codes.	• Requires large amounts of secondary data to estimate the probability distributions of key input variables. • Assumed shapes of the distributions may be inaccurate. • Requires a basic understanding of probability theory to set up and interpret.

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