

Seven Years Since SERP: Successes and Setbacks in Technology Procurement

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ABSTRACT

The past seven years have seen a variety of projects designed to aggregate markets for highly efficient products and to induce manufacturers to respond with improved technology. In addition to the Super-Efficient Refrigerator Program (SERP), which initiated sales in 1994, a Consortium for Energy Efficiency-led apartment-size refrigerator program and DOE-led procurements of high-efficiency clothes washers, sub-compact fluorescent lamps, recessed downlight fluorescent fixtures and commercial packaged air conditioners all form a rich body of experience from which to extract lessons for similar procurements in the future. How can one identify promising candidate products? What factors induce manufacturers to respond aggressively? Do responsive manufacturers have identifiable characteristics? Are guaranteed sales or exclusive vendor selection essential? What partners and promotion activities are essential for success? How much time is involved at each stage? What about product testing and validation of performance claims? This paper addresses these and other questions, drawing on DOE's, PNNL's, and other organizations' experience designing, conducting, and evaluating technology procurements since the time of the SERP project.

Introduction

In 1999, Pacific Northwest National Laboratory (PNNL) evaluated three U.S. energy-efficient technology procurement projects for the primary purpose of gleaning key learned lessons, so that future practitioners of technology procurement might develop better programs and avoid costly mistakes (Marc Ledbetter et al. 1999). This paper provides an updated summary of the original three projects, describes three additional ones, and reviews the lessons learned in light of recent events. The procurement projects that will be discussed are the following:

- *Super-Efficient Refrigerator Program* – a project implemented by a consortium of electric utilities whose primary intent was to induce a refrigerator manufacturer to introduce to the market a new, highly efficient refrigerator that exceeded U.S. government minimum energy efficiency standards by at least 25%, yet cost no more than similar refrigerators with normal energy efficiency.
- *Apartment-Sized Refrigerator Purchase* – organized by the Consortium for Energy Efficiency (CEE), the New York Power Authority, the U.S. Department of Energy (DOE), and the New York City Housing Authority. The purpose was to induce market introduction of high-efficiency apartment-sized refrigerators and to save energy costs in public housing in New York and other cities by holding a competition to supply a large number of identical high-efficiency refrigerators to replace out-of-date ones.

- *DOE High-Efficiency Clothes Washer Volume Purchase* – a project implemented by DOE and the City of Austin, Texas, whose primary intent was to build early, high-volume sales for high-efficiency clothes washers that had just been introduced to the U.S. market.
- *DOE Sub-Compact Fluorescent Lamp (CFL) Technology Procurement* – a project whose primary intent was to introduce shorter, brighter and more affordable sub-CFLs to the marketplace. These new screw-base CFLs were significantly smaller than the current generation of CFLs, and available in volume prices.
- *High-Efficiency Unitary Air-Conditioner Technology Procurement* – an ongoing project involving the U.S. Department of Energy, the Defense Logistics Agency, and private-sector buyers with an interest in purchasing “rooftop” air conditioners at minimum life-cycle cost, taking into account energy consumption as well as initial price.
- *Recessed Downlight Fluorescent Fixtures* – a procurement designed to elicit new technologies that would permit compact fluorescent lamps to operate reliably in airtight recessed fixtures installed in insulated ceilings, where heat buildup can seriously degrade performance.

Project Results

Super-Efficient Refrigerator Program

In 1991, a group of U.S. electric utilities formed a consortium, the Super-Efficient Refrigerator Program, Inc. (SERP), whose mission was to advance the technology of refrigerators and to bring energy-efficient and environmentally friendly refrigerators to consumers years before they would be available under normal market conditions. After securing commitments of participation from 24 electric utilities, SERP issued a request for proposals (RFP) in July of 1992 to refrigerator manufacturers stating that the manufacturer who offered the most energy savings at the lowest cost per kilowatt-hour saved was to win up to \$30 million of incentive money, depending on the ratio of incentive to first-year kWh savings and provided that the manufacturer could sell enough qualifying models within the service areas of the participating utilities (Feist et al. 1994).

Fourteen manufacturers submitted bids in response to the RFP. In December 1992, SERP announced Frigidaire and Whirlpool as finalists and both were required to submit prototypes for testing. Ultimately, Whirlpool was selected as the winner, qualifying for the full amount of the incentive pool at a cost of less than \$0.375 per kWh saved. The winning bid proposed a combination of refrigerator sizes (22, 25, and 27 cubic feet). All three incorporated automatic defrosting, side-by-side and through-the-door water and ice features, and they all exceeded the 1993 federal standard for energy efficiency by 29.7% to 41%. The first SERP models were shipped to dealers in February 1994.

Unfortunately, Whirlpool stopped manufacturing the SERP units in 1998 after selling substantially fewer than the 250,000 units it had proposed. Evaluators were unable to learn the exact number of units sold (Lee and Conger 1996).

Several possible reasons could explain why sales were lower than expected. One is that the SERP model was a large, high-end product with a relatively high price when compared to the majority of refrigerators sold on the market. The bid scoring system

provided a strong incentive to Whirlpool to bid large refrigerators because the system gave credit for the number of kWh saved, rather than a percentage of kWh saved.

Another possible explanation for lower-than-expected sales was lack of effective promotion of the units. One evaluation of the SERP program found that inadequate dealer awareness and salesperson understanding of the rebate structure and sales tracking requirements contributed to decreased sales of the units (Lee and Conger 1996).

Despite the low sales, SERP appears to have been responsible for much of the increase in the overall efficiency levels of Whirlpool's side-by-side units in the years following the launch of SERP, as well as a modest increase in the efficiency levels of other brands (Lee and Conger 1996). Also, federal efficiency standards generally increased over the 1993 levels by roughly the same percentage improvement SERP achieved, although opinions differ concerning the correlation. One of the principals involved in the development of those standards stated that the SERP refrigerators had an impact on the standards. Yet a Whirlpool representative reported that the similarity between SERP efficiency levels and the new standards was a "coincidence" (Sandahl et al. 1996).

Super-Efficient Apartment-Sized Refrigerator Initiative

In 1995, building on the SERP experience, the New York Power Authority, the New York City Housing Authority, CEE, and DOE organized a procurement to challenge manufacturers to furnish 15-cu. ft. refrigerators that substantially exceeded the national efficiency standards at the time. The refrigerators were initially to replace older, less-efficient refrigerators in New York City public housing projects. Through the team's marketing efforts, several thousands of the winning units were later purchased by other low-income housing agencies around the country (Wisniewski and Pratt 1997).

Each of the organizations involved brought critical elements to the success of the project. The New York Power Authority used its technical and financial resources to administer the procurement and to finance the purchase, and the city housing authority provided the initial purchase commitments. DOE helped to broker an arrangement with the U.S. Department of Housing and Urban Development (HUD), under which HUD would reimburse the housing authority for the cost of acquisition and installation, provided the energy savings were adequate to justify the investment. PNNL and the NY State Energy R&D Authority also developed and applied the monitoring and validation scheme that was necessary to satisfy the requirements of the financing agreements with the power authority and HUD (Miller and Pratt 1998a). CEE, as an outgrowth of the SERP program, contributed its experience throughout the process, enlisted the support of member utilities around the country, and in collaboration with DOE, promoted the purchase of additional refrigerators in other cities.

The procurement took place in two initial stages. With commitments to buy 20,000 units in each of four years from the housing authority, the power authority issued the first RFP in May 1995 and awarded a contract to GE for supplying an existing 14.4-cu. ft. Hotpoint model. In 1996, the power authority issued another RFP for purchases in the following year, and Maytag won the award with a new-to-the-market 15.1-cu. ft. Magic Chef model rated at 437 kWh/yr, a 31 percent improvement over the national efficiency standard. Maytag agreed to make additional units available through the contract, and by the end of

1996, CEE and DOE had successfully promoted orders for more than 70,000 units from utilities and housing agencies in other parts of the country.

Since then, HUD has formalized financing incentives for energy conservation improvements, like the refrigerator replacements, in its public housing operating fund regulations (24 CFR 990.107 (f)), and Maytag continues to offer the apartment-sized Magic Chef model for sale. In 1999, the Los Angeles Department of Water and Power obtained an offer from Maytag for a larger, 18.5-cu. ft. refrigerator, with a rated energy consumption of 485 kWh per year, which added another unit to the CEE initiative. Finally in 2001, Maytag improved the efficiencies of both the smaller and larger models to levels of 386 and 440 kWh/yr, respectively, bringing them into compliance with current Energy Star[®] requirements. Sales over the life of the program are approximately 250,000 units (CEE 2002).

Although perhaps more modest in scope than SERP, the apartment-sized refrigerator initiative has been a success. Some of the features that contributed include a large initial buyer with solid financial backing, staged solicitations and other provisions to allow for gradual improvements in technology over time, technical resources from a major power supplier and a national laboratory, and long-term commitment to promoting the products by a national consortium of utilities and other organizations concerned with market transformation.

DOE High-Efficiency Clothes Washer Volume Purchase

Although resource-efficient, high-performance horizontal-axis clothes washers use significantly less energy and water than conventional vertical-axis clothes washers, the initial cost of these machines is significantly greater than the price of conventional vertical-axis washers. In 1997, only one major U.S. manufacturer (Frigidaire) was offering horizontal-axis clothes washers, and they had only been on the market a short time.

In order to help establish the initial market presence of high-efficiency clothes washers, DOE commissioned PNNL to develop a volume purchase program in partnership with the City of Austin, Texas. After extensive consultations with clothes washer manufacturers and municipal water utilities, which were expected to be the primary users of the program, an RFP was issued in September of 1997 to potential suppliers of high-efficiency clothes washers to offer washers to the City of Austin and other as yet unnamed volume purchase partners. The RFP contemplated Basic Ordering Agreements (BOAs) with suppliers for the volume delivery of high-efficiency machines at attractive prices to municipal water utilities, energy utilities, public housing agencies, and other government entities. The machines had to meet minimum technical specifications and other conditions described in the RFP. Program partners seeking to take advantage of the machines at the prices and terms specified in the BOAs were responsible for developing their own programs for delivery of these machines to their final owners. DOE offered technical assistance for the development of those programs (Edgemon, Gregg, and Baechler 1998).

PNNL received three proposals in response to the RFP, and in December 1997, negotiated a BOA with Sides Supply, Inc., the winning bidder. Although they considered it, Austin decided not to purchase and resell the clothes washers directly to customers, but instead asked local retailers to participate in the program. Retailers were offered the chance to take advantage of the city's clothes washer promotional program in exchange for

warehousing and displaying the washers and dryers and providing delivery and installation services to Austin customers. Austin also offered rebates to city water customers purchasing any clothes washer meeting Energy Star^{®1} specifications (minimum energy factor of 2.5) from any retailer. These rebates amounted to \$150 per washer for customers with electric water heaters and \$100 per washer for customers with natural gas water heaters. The city rebated an additional \$30 to customers purchasing the volume purchase program Gibson Tumble Action Washer prior to June 30, 1998. When Austin's program was launched, several local retailers complained that the city should not be getting in the business of promoting a particular washer that competed with washers they were selling. They viewed it as unfair competition by the city. The city responded by offering all appliance retailers the opportunity to sell program washers and take advantage of the city's promotional program.

About two months prior to the scheduled expiration date of the BOA, Sides Supply and Frigidaire informed DOE that they did not wish to exercise the option of extending the BOA for another year. Frigidaire informed DOE that they were selling 100% of their production through other channels, and it therefore didn't make sense to continue selling the heavily discounted washers through this program.

Program staff viewed the High-Efficiency Volume Purchase program as a mixed success. The staff viewed several program outcomes as disappointing:

- Only 579 washers were sold relative to the goal of 10,000 units.
- Only two municipal partners took advantage of the program.
- The controversy with retailers in the Austin area made some potential municipal partners reluctant to participate in the program.
- The BOA was terminated after one year; neither of the two optional one-year extensions was exercised.

While sales were disappointingly low compared to the sales target, staff viewed several program outcomes as indicators of partial success:

- Bids in response to the RFP were aggressively priced, especially the winning bid, which offered washers for approximately \$300 less than prevailing retail prices.
- Program washer sales were robust in the City of Austin.
- Although they needed more time than was allowed, several other potential municipal partners attempted to develop programs to take delivery of the washers.
- The program was terminated because the washer manufacturer was able to sell 100% of its production without the assistance of this kind of program.

DOE Sub-CFL Technology Procurement Program

This technology procurement initiative was designed by PNNL on behalf of DOE to spur the market introduction and sales of smaller, affordable, high-quality CFLs. Discussions with public housing managers involved in the apartment-sized refrigerator program and subsequent market research indicated that the primary barriers to increased sales of CFLs to

¹ Energy Star[®] is a registered mark of the U.S. Environmental Protection Agency licensed to the U.S. Department of Energy.

volume buyers were high CFL prices and the difficulty of fitting CFLs in many common lighting fixtures. The program was designed to help reduce the price of CFLs to volume buyers and to encourage manufacturers to offer smaller-sized CFLs to the market. (The program labeled these smaller lamps “sub-CFLs.”)

After a brief pilot stage, the program started in earnest in October of 1999. Five winning bidders sold their products in minimum quantities of 6 to 10 lamps directly to volume buyers, such as multi-family building owner/operators, universities, public housing authorities, hotel/motel companies, federal agencies, utilities, and lighting product resellers. DOE hosted a web site, which provided technical and pricing information, and directed purchasers to the five suppliers. Although most early utility CFL programs had declined prior to the Sub-CFL program, and none involved sub-CFLs, utilities were responsible for the large majority of early program sales. Over time and as program planners had hoped, retailers and other groups began to purchase lamps as awareness of sub-CFLs grew. DOE offered no financial subsidies to buyers; however, some utilities offered coupons or other incentives for sub-CFLs.

The program continued through May 2001, when the Northwest Energy Efficiency Alliance assumed management of the program and launched a new, private venture to support retail sales of sub-CFL products in the mainstream marketplace. Among the highlights of the Sub-CFL Program’s accomplishments:

- Fifteen new sub-CFL models were introduced by participating manufacturers.
- The term “sub-CFL” became common in the marketplace.
- The program had broad impact on the technical specifications for CFLs used by various organizations and companies that promote use of CFLs – and by Energy Star[®] in their eventual CFL specification.
- At the start of the Sub-CFL Program in 1999, CFL retail prices for short 15-watt lamps ranged from \$15 up to \$28. By August 2001, buyers could purchase sub-CFLs for as little as \$6.99 each.
- Over 3 million lamps were reported sold by participating manufacturers since the program’s inception. The program’s sales goal was 1 million sub-CFLs.
- The program was successful in attracting support from utility programs, which accounted for a large volume of early sales and eventually took over continuing operation.
- Possibly in response to the new lamp models introduced by the program, GE introduced a triple U-tube and a spiral sub-CFL, and Osram Sylvania has introduced a spiral product as well.

Ongoing Procurements

DOE is currently conducting two procurements designed to take advantage of the experience derived from past programs and to apply it to newly identified opportunities. One procurement involves packaged “rooftop” air conditioners for commercial buildings, and the other is for recessed downlight fixtures for compact fluorescent lamps.

Rooftop air conditioners. Discussions with researchers, manufacturers, and buyers identified light commercial unitary air conditioners as a promising target for the technology

procurement approach. The federal government, a major buyer of air conditioners, had received executive orders, notably Executive Order 13123, requiring agencies to purchase efficient equipment and thereby minimize life-cycle cost (Executive Office of the President, 1999). Manufacturers indicated that if significantly more buyers based their purchasing decisions on life-cycle cost, rather than first cost, they could improve the efficiencies of the products they offered for sale, especially if partial-load performance were taken into account. Among the technology options were several ways to increase heat-transfer surface area, heat-transfer coefficients, and compressor and fan efficiency, as well as to improve capacity control, utilize electronic expansion devices, and employ liquid overfeed technology.

In consultation with the Federal Energy Management Program, the Defense Logistics Agency, and several energy service companies and other national air conditioner buyers, a new DOE-sponsored program developed a set of product specifications and a simple method of estimating life-cycle cost. The cost estimation method, embodied in a spreadsheet, takes into account hourly temperature and humidity conditions and reflects energy consumption by a given air conditioner corresponding to those conditions throughout a typical year. The consumption data can then be combined with applicable electric rates and the initial price of the unit to derive its life-cycle cost. These specifications and the cost estimator form the core of a request for proposals for unitary packaged air conditioners between 65,000 Btu/hour and 135,000 Btu/hour, issued by Pacific Northwest National Laboratory on behalf of the Department of Energy and the Defense Logistics Agency in January of this year. Four proposals were received in March, and to qualify, efficiencies were required to meet or exceed CEE Tier II levels.² Winners selected according to the evaluation criteria are to be awarded basic ordering agreements allowing buyers to acquire the units on established price and delivery terms offered by the bidders.

Much of the impetus for issuing the RFP, and incentive for responding to it, arose from the Defense Logistics Agency's plans to offer the winning units for sale to both military and civilian federal agencies. Additional inducement took the form of expressions of interest from private sector buyers in purchasing winning units, and the Department of Energy articulated plans to publicize the availability of the units through its efficiency programs. Finally, CEE's High Efficiency Commercial Air Conditioning and Heat Pump Committee expressed its intent to consider using the efficiency of the winners as the basis of a future efficiency specification tier for its initiative.

Recessed downlight fixtures. Residential recessed downlights have been identified as an energy-intensive product in need of design improvements, so DOE is sponsoring a program to introduce new, highly-efficient residential recessed downlights into the market. Recessed downlights are by far the most popular residential lighting fixture for new construction in the United States. The Census Bureau reports that 20.4 million of these fixtures were sold in 1999. Although precise numbers on the installed stock are not available, 150 million or more downlights are probably now installed in American homes. Virtually all use incandescent light bulbs, so a cost-effective equivalent designed to accept hard-wired CFLs represents an opportunity for energy and cost savings. The difficulty lies in designing recessed downlights

² CEE's High-Efficiency Commercial Air Conditioning and Heat Pump Initiative (HECAC) was launched in 1994 to encourage the widespread use of high-efficiency unitary central air conditioning and heat pump equipment. Working with member organizations, CEE developed two levels of specifications for use in public benefit energy-efficiency programs.

that are airtight, rated for insulated ceilings (type IC), and at the same time do not overheat and degrade the fluorescent lamps and ballasts.

The program, implemented by PNNL, applies the technology procurement approach to induce manufacturers to offer downlights that can be installed in insulated ceilings, minimize air leakage, and meet a set of requirements for proper operation of CFLs. RFPs were issued in November of 2000 and July of 2001. Proposed products from those solicitations are currently undergoing laboratory testing in a simulated insulated ceiling environment. Qualifying fixtures will undergo field-testing in new and remodeled homes starting in the summer of 2002. PNNL plans to offer ordering agreements to manufacturers of products that pass required laboratory and field tests. A recently developed web site (www.pnl.gov/cfldownlights) houses the technical specifications and information about the project. Products should be available for purchase early in 2003.

Lessons Learned

Evaluation of the technology procurement programs discussed in the preceding sections and consideration of what did and did not work during program development, design, and implementation yield a number of lessons for consideration by others in devising technology procurement programs. The lessons are discussed below.

Program Development Lessons

*The program development process should be **buyer-driven**. The interests of buyers, their issues and concerns, market perspectives and willingness to buy must largely determine development and design of a program.*

Perhaps the best example of this lesson comes from the DOE CFL Technology Procurement Project. DOE invested almost a year in working with the private multi-family owner/operator industry (PMFO). DOE explored this industry's interest in efficient household appliances and found it was high among some major companies initially, but management changes in those companies and the new managements' concerns about the cost of efficient appliances caused those companies to lose interest. Furthermore, other PMFOs were reluctant to make such investments at the outset. Subsequently, DOE explored the possibility of working with these companies on a project focused on Energy Star[®] lighting fixtures and again encountered the same resistance. Companies argued that the labor and capital costs of new lighting fixtures were still too high for them. Only when DOE proposed the low-cost measure of retrofitting integral CFLs in fixtures designed for incandescent lamps did the PMFOs respond with interest. They made it clear that they would be interested in buying these lamps, if they were smaller, cheaper and brighter, which were all used as primary design goals for the DOE Sub-CFL Technology Procurement project.

Sometimes improved energy efficiency goes hand in hand with other product benefits. For example, an energy-efficient dishwasher runs more quietly than a standard model because of added insulation that serves as a sound barrier. In the Sub-CFL Program, early market research indicated that product specifications needed to include reduced lamp length, elimination of buzzing, reduced glare and ease of installation. Since non-energy features are often more compelling reasons to buy an energy-efficient product than are the energy savings, they should be highlighted in program development and product promotion.

Even though program development should be buyer-driven, developers should nonetheless seek out suppliers and distributors to learn about their perceptions and motivations and to communicate effectively with existing players, especially companies that might perceive the program as a competitive threat.

All of the technology procurement projects reviewed in this report engaged manufacturers extensively during the program development phase and these efforts consistently yielded good information concerning the reasonableness of proposed technology specifications and the capability of manufacturers to meet them. An example of the importance of these discussions can be found in the DOE Sub-CFL Technology Procurement project. In developing the specifications for these lamps, DOE first considered specifications that had been developed by EPA for the Energy Star[®] Lighting fixtures program and other CFL programs run by electric utilities. Many of these programs contained a specification requiring that the power factor for CFLs be at least 0.9 and the current total harmonic distortion not exceed 33%. CFL manufacturers unanimously agreed that these requirements were unnecessary. An investigation, involving many parties, including target buyers, concluded in the end that the power quality requirements should be much less stringent. Later, in the course of negotiating a consensus on the Energy Star[®] CFL specifications, several large electric utilities decided to reduce the stringency of their power quality requirements.

The experiences of both SERP and the DOE High-Efficiency Clothes Washer programs indicate that implementation problems could have been avoided with better understanding of the delivery channels used in those projects. In the case of SERP, a large number of retail stores were unaware of the availability of manufacturer-provided rebates for selling SERP units. Consequently, SERP units were priced much higher at many of those stores than they would otherwise have been, which hurt the consumer attractiveness of these models.

In the case of the DOE Clothes Washer Program, a number of retailers in the Austin area viewed the program as a competitor to their business. Only after a controversy arose did Austin program staff, with the help of Sides Supply, engage these retailers, consider their issues and then implement the program in a way that calmed the controversy. In the opinion of Austin's local program manager, had Austin never raised the possibility of the city directly buying and reselling clothes washers to its citizens, the controversy would not have materialized.

In procurement projects aimed at products that have relatively low capital requirements for starting new production, small manufacturers can be important agents of change in the market.

SERP required refrigerator producers to demonstrate manufacturing capability, ability to distribute nationwide, and corporate reliability and capital resources to pursue the program (Feist et al. 1994). In the DOE clothes washer program, the capital requirements for clothes washer production, consumer preference for name-brand products, and prior knowledge of which companies were capable of producing the required product all weighed heavily in favor of working with a major manufacturer. Bids from small producers were not ruled out; they just weren't expected, and therefore little effort was expended in interacting with small potential bidders.

On the other hand, the DOE Sub-CFL program had elements that increased the attractiveness and likelihood of working with small companies. Several small companies had shown innovative products at recent trade shows; buyers had displayed a willingness to buy products from small producers; and the capital requirements for developing and producing new CFLs were substantially lower than for refrigerators or clothes washers, especially considering the practice of having lamps produced under contract by existing large manufacturing facilities (many located in China). Furthermore, these companies did not already enjoy large market shares, a condition that might otherwise have given them a stake in continuing to supply traditional products. PNNL thus invested significant time interacting with small CFL producers. Several of these producers were awarded BOAs in the program. They have proved to be nimble in bringing forth new product and in seizing market opportunities. Two of these producers were able, in less than two months time, to redesign products in response to DOE suggestions and submit prototypes for DOE's review.

Choice of target technology can strongly influence the success of a procurement project.

Target technologies are more promising if they meet the following requirements:

- Products or features are attractive to a large number of motivated buyers.
- Products or features are not already widely available.
- Products are standardized and mass-produced, not custom-designed.
- More than one supplier is in a position to compete for the procurement.
- Desired changes in products or processes are not so fundamental as to require long lead times for R&D.
- The technology advances the developer's strategic goals, e.g., reduced energy consumption.
- The technology brings with it partners and allies to help promote purchases.

Program Design Lessons

Unless circumstances strongly indicate otherwise, it is preferable to make more than one award in response to competitive solicitations.

Of the programs reviewed in this paper, three made single awards in response to competitive solicitations: SERP, the Apartment-Sized Refrigerator, and the DOE High-Efficiency Clothes Washer programs. The DOE Sub-CFL program made multiple awards, and both of the two ongoing procurements envision more than one award.

SERP program designers made a deliberate decision to make only one award, because they believed that offering more than one would dilute the financial benefit to the winner. This decision was made after intense debate among the designers, many of whom argued that making a single award made the program too dependent upon a single company. Later on, sole dependence on Whirlpool caused implementation problems for SERP, since Whirlpool marketed the refrigerators more slowly and less aggressively than they had expected.

Program designers for the DOE High-Efficiency Clothes Washer program expressed a clear preference for multiple awards, but after scoring the bids received in response to the RFP, there was only one clear winner, so a single BOA was awarded. When Frigidaire

announced that it did not want to continue supplying the program into the optional time extension period, the program was left without another supplier it could turn to.

The designers of the DOE Sub-CFL program knew that capital requirements for producing new CFLs and market conditions weighed in favor of multiple awards, and the program has benefited greatly from having more than one supplier. For example, one of the companies originally awarded a BOA was suspended from the program, but with three other suppliers already approved, the setback for the program was minor. Also, multiple suppliers served to increase the variety of products available to buyers.

If market and technology conditions allow it, an initial phase solicitation can be very useful in identifying potential suppliers and buyers, appropriateness of specifications, and functionality of program logistics.

The Apartment-Sized Refrigerator, DOE Sub-CFL, and Recessed Downlight programs all entailed initial phases that built buyer interest and manufacturer confidence and provided useful information about markets and technology for the people responsible for design and implementation of subsequent stages. A second phase is anticipated for the rooftop air conditioner procurement. In all three cases, the initial demonstration achieved modest results in terms of product offerings but helped to demonstrate the extent and seriousness of buyer interest, identify potential suppliers, and calibrate the appropriateness of the specifications.

Our experience also suggests that a new model of technology procurement should be considered for technologies needing a year or two of development prior to commercialization. The model would use a two-stage process, with each using a competitive solicitation. In the first stage, proposals would be solicited from companies interested in receiving technical and financial assistance to engage in late-stage technology development. Winning bidders would be those companies offering significant cost sharing, evidence of the appropriate technical knowledge, and superior product concepts or prototypes. These winning bidders then could receive technical and financial assistance to refine and improve their products, bringing them to the point of imminent market introduction.

In the second stage, the pool of winning bidders from the first stage would be asked to compete for the opportunity to provide high-volume quantities of their new product to pre-arranged buyers groups and other volume purchasers. Winning bidders would offer superior prices, products with superior performance, and demonstrated ability to fulfill the purchase orders anticipated.

This two-stage approach would use competitive solicitations in two ways; one to narrow the pool of companies offered technical and financial assistance, and the other to choose the best among those companies to provide assistance with commercialization. In so doing, the project sponsor can focus its resources on those companies most likely to succeed with new product commercialization.

Although technology procurement projects have heavily relied upon guaranteed sales or exclusive access to large financial awards (SERP, Apartment-Sized Refrigerators), DOE's clothes washer and sub-CFL programs have demonstrated that they are not always necessary to attract aggressive bids, especially when attempting modest incremental improvements in technology, not big leaps forward.

SERP did not require a radical improvement in refrigerator technology, but the technology change required a substantial investment by Whirlpool in its production line, so this change might not have been achieved without the prospect of exclusive access to utility rebate funds. The same was also probably true for the apartment-sized refrigerators. The DOE clothes washer and Sub-CFL program, on the other hand, sought relatively modest improvements in technology and relied primarily on offering bidders attractive selling opportunities, rather than guaranteed sales. In the case of the sub-CFL program, bidders were offered DOE's assistance in helping them access certain target markets. Bidders indicated that having DOE involved helped them establish credibility for their products. Bidders for the DOE clothes washer program were offered similar assistance, including Austin's consumer rebates. In both programs aggressive bids were received and bidders indicated, both through the action of their bids and through subsequent questioning, that the absence of guaranteed sales in being awarded a BOA did not make them reluctant to bid (Scott, Parker, and Currie 1998). Had they sought larger improvements, it is less likely that the programs as designed, without large volumes of guaranteed sales, would have succeeded in inducing manufacturers to bring new products to market.

Technology procurement programs that depend on sales to large volume buyers, particularly government agencies, should be designed to allow a long period of time (at least two years) for the target buyers to purchase product.

Large companies, institutions and especially government agencies typically have rigid purchasing processes that work best when they continue to purchase items they normally purchase, through the same channels they normally use. When they are asked to consider purchasing new products - especially ones that are more expensive than their normal purchases - processes typically slow down, many more people are involved in the decisions, regulatory or company policy barriers are encountered, and the purchase gets bogged down. If this time-consuming process is not accounted for in the program from the beginning, the risk of program failure increases.

The DOE clothes washer purchase, the Super-Efficient Apartment-Sized Refrigerator Program, and the Rooftop Air Conditioner Procurement are all good examples. Clothes washer program developers underestimated the amount of time it would take municipal water agencies, housing authorities, and large project developers to work through the process of buying washers through the program. The Consortium for Energy Efficiency heavily marketed the program to public housing authorities around the country. Many of those purchases required extensive amounts of technical and logistical assistance, and most of them took many months to put in place. Collaboration with the Defense Logistics Agency has added approximately 18 months to the administration of the rooftop air conditioner procurement, due to staffing limitations, legal reviews, and management approvals. In each case the buyers operated under different sets of resource and time constraints and had their own unique internal decision-making processes.

Involving trusted institutions that are recognized for objectivity, consumer interest, or technical expertise in the development and implementation of technology procurement programs can contribute significantly to their success, but credible independent testing and evaluation of products can be costly.

In all of the programs reviewed here, both companies and individuals that have participated have cited the importance of having DOE, PNNL, utilities, or other trusted independent organizations involved in the programs. DOE, as a federal government agency, helps the programs to be perceived as fair, objective, and in the interest of consumers. PNNL, as a DOE national laboratory, offers technical credibility to buyers and product developers. And the utilities' customers frequently trust their recommendations on new technologies.

Credible evaluation of products sometimes requires substantial resources for developing new testing methods and obtaining use of needed laboratory facilities. Since the procurements may address technical shortcomings in the products already available in the market, new test methods may be needed to ensure that the new products can overcome these problems. Cost-effective, practical testing protocols had to be devised for both the Sub-CFL and Recessed Downlight procurements, and field monitoring was a critical element of the financing arrangement for the Apartment-Sized Refrigerators.

Technology improvement achieved through competitive procurements does not have to end with the initial market introduction of the new technology. Further technology improvements can occur during the implementation of the program, and programs should be designed to take advantage of them.

The best example of this lesson can be found in the Sub-CFL programs. DOE required independent testing and verification of compliance with program technical specifications for all products sold through the program. But to avoid delays in product introduction, DOE allowed extended testing to occur after product sales began, as long as manufacturers submitted certification prior to sales that they met all technical specifications and honored the applicable warranties.

During the program's implementation, independent testing arranged by DOE revealed that some models from some suppliers fell short of certain specifications. Depending on the severity and type of deficiencies found, either DOE pulled the deficient product from the market immediately, or the manufacturer corrected the deficiency while the product stayed on the market. This approach helped three program suppliers identify and correct performance deficiencies.

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