

Innovation in Manufactured Housing Energy-Efficiency Programs

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The manufactured housing industry has undergone some major changes in the Pacific Northwest. Drafty mobile homes with a reputation for low quality and energy efficiency performance may become a thing of the past thanks to some innovative programs to upgrade manufactured housing sponsored by Northwest utilities and the Bonneville Power Administration. Utilities started paying attention to manufactured housing in the mid 1980s when they learned that up to 50% of new houses sited in their areas were manufactured homes. Preliminary studies indicated that huge energy savings were possible in these homes, more than 50% over the life of the home.

Bonneville's first coordinated effort to study the situation was the Manufactured Housing Work Group which was established in the fall of 1986 and included manufacturers, utilities, the Northwest Power Planning Council (the Council), the Pacific Northwest Laboratory (PNL), trade associations, and regulatory agencies. The Work Group recommended energy programs for manufactured housing based on Bonneville's conservation programs for site-built homes: the Super Good Cents Program (SGC) and the Residential Construction Demonstration Project (RCDP). Research results from the RCDP/SGC Manufactured Housing Program included collection of metered energy end-use data and cost data on individual conservation measures, cost effectiveness analyses, and computer modeling. This research provided Bonneville the data required to recommend the best tactics for keeping the manufactured housing industry on its new-found course of energy efficiency, a direction that is sure to mean higher quality homes for the consumer and energy savings for regional utilities.

Introduction

Although technology is changing rapidly in many fields, the home construction and utility industries are still viewed by some as reluctant to adopt new ideas. However, in recent years utilities and home builders in the Pacific Northwest have undergone significant changes in attitude toward product improvement with regard to energy efficiency. One of the more surprising facets of this attitude adjustment has been the changes in the manufactured housing industry. The importance of these changes, and the innovative way in which they came about, are the topic of this discussion.

Background

The Bonneville Power Administration (Bonneville) is a federal power agency which markets electric energy from several hydro-electric projects and acts as a regional power distribution network. Bonneville services about 130 public and 7 private utilities throughout the Pacific Northwest which consists of four states: Washington, Oregon, Montana and Idaho.

The Pacific Northwest Electric Power Planning and Conservation Act. In 1980, Oregon, Washington, Idaho, and Montana participated in the enactment of the Pacific Northwest Electric Power Planning and Conservation Act, Public Law 96-501 (the Act). The conservation of electricity was given a major role in the Act. From this act, the Northwest Power Planning Council (the Council) was created. The Council works closely with Bonneville to develop cost-effective and regionally acceptable power sources and to reduce electric loads in the residential sector through conservation and renewable resources. Bonneville has taken a lead role by coordinating regional utilities in these efforts.

Model Conservation Standards. One of the many tasks set forth under the Act was to prepare Model Conservation Standards (MCS) for residential buildings. The MCS first appeared in 1983 and were directed at new electrically heated site-built residences under the region's first power plan. The second power plan, issued by the Council in 1986, reiterated the basic requirements of the MCS. Both plans stressed the importance of conservation and renewable resources.

Bonneville Research and Marketing Programs for Energy-Efficient Site-Built Housing. Before Bonneville began its energy efficient manufactured housing programs, it already had several years of experience exploring innovative methods for researching and marketing the construction of energy-efficient site-built homes.

The Super Good Cents Program. Super Good Cents is a marketing program coordinated by Bonneville and operated by participating regional utilities that promotes energy savings in electrically heated homes. Bonneville's SGC program for site-built homes was operating in the region by 1985. Later, because expected penetrations into the new housing market were not being met, financial incentives were added to interest builders and potential home buyers. The original incentives ranged between \$2,500 to \$3,500 but by 1988 (the year that manufactured homes were included) Bonneville decreased the incentives to \$1,000, \$1,250, and \$1,500 per home, depending on the regional climate zone in which the home was built.

The Residential Construction Demonstration Project. Like SGC, the RCDP was also an operating program in the mid-1980s. Begun in October 1985, it was designed to demonstrate new residential building techniques and product innovations that advance the state of the art in construction of electrically heated residences. This original work was designed to document the cost-effectiveness of various ECMs for site-built MCS homes.

This early experience with the SGC and the RCDP proved useful in the design and implementation of the manufactured housing strategy.

Title VI and HUD. Under Title VI of the Housing and Community Development Act of 1974, Congress determined that it was necessary to establish the Federal Manufactured Home Construction and Safety Standards (FMHCSS) for the manufactured home industry. Manufactured homes covered by Title VI are often called "mobile homes" or sometimes "HUD-code manufactured homes."

The Department of Housing and Urban Development (HUD) was given the authority to promulgate a reasonable standard for the construction, design, and performance of manufactured homes, which it did in 1976. One major provision of Title VI states that "No State or locality may establish or enforce any rule or regulation or take any action that stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress." Often referred to as the preemption and reciprocity clause it gave the industry a single national

standard free from state and local jurisdiction. With reciprocity, a home produced in one state could be shipped to another without difficult and costly inspections or costs which today plague the modular and panelized home industries. Manufacturers in Washington state could build a home for shipment to California, Alaska, or even Hawaii without inspection requirements beyond the plant boundaries. The preemption clause allowed the industry to become a very competitive force in providing affordable housing to the nation.

Manufactured Housing: the Untapped Resource

By the mid-1980s the Northwest utilities had worked hard to include MCS construction requirements in the site-built housing industry. However, little attention was paid to Title VI manufactured homes. There were good reasons for this. No utility was tracking manufactured homes sited in its territory. Existing utility programs were directed at the local home builders through training, seminars, design assistance, and later with cash incentives. The preemption clause of the HUD-code prevented local jurisdictions from considering applying a building standard to manufactured homes. It wasn't until initial studies conducted by Bonneville revealed that over 10,000 manufactured homes were being sited annually (and these homes were generally inefficient) that the industry got closer attention from Bonneville.

Bonneville's Early Studies

Prior to 1986 Bonneville had already completed several manufactured housing studies and projects. Notable among these were the construction and monitoring of 5 energy-efficient homes and participation in the upgrade of 35 manufactured homes for the Tulalip Indians in Washington state (Lee et al. 1986). Both of these projects suggested the technical feasibility of building energy-efficient homes at a reasonable cost. However, they did not determine the energy savings and the more precise cost-effectiveness for each energy conservation measure (ECM) that could be used in manufactured housing.

Bonneville was convinced by these and other studies (e.g., Lee et al. 1988 and Harkreader, Lee, and Sherman 1987) that the potential for energy savings in the manufactured housing sector was large. Indeed, estimates suggested that well over half of the energy use of manufactured homes could be eliminated through the application of ECMs. For utilities, these savings were cheaper than the cost of

energy from a new coal-fired power plant. In the Pacific Northwest the cost of electricity from a new coal-fired power plant is used to set the bench mark avoided cost to evaluate other electric energy resources.

Manufactured Housing Work Group

The first coordinated regional effort to establish a manufactured homes program began with the creation of the Manufactured Housing Work Group (Work Group) in November 1986. Invited members included manufacturers, utilities, trade associations, regulatory agencies, the Council, PNL, and Bonneville. The Work Group's immediate task was to establish working relationships among the various members and to lay the groundwork for a regional manufactured housing program.

Bonneville and the utilities were fully aware of the preemption clause and the effect it would have on any regional program. From the outset it was clearly understood that any participation by the manufacturers would be strictly voluntary.

The first Work Group meeting produced mixed results. The attitudes and opinions discussed seemed extremely divergent, but still it was productive.

Utilities better understood manufacturers and vice versa. Manufacturers were concerned about "conservation program" impacts on their industry. For example, they worried about additional regulations or inspections beyond what HUD already required.

The Work Group also learned that the manufacturers were not a homogeneous group building the same home to a limited market. In reality, manufactured homes covered a wide range of styles, types, and associated costs, and they were bought by a wide range of consumers. This meant that building upgraded homes could be easy and inexpensive for some manufacturers while it could be difficult and costly for others. Many questions were raised about the technical and cost feasibility of upgrading manufactured homes to an equivalent MCS standard.

After reviewing previous reports and information gathered to date, the Work Group participants set about to design a work plan to improve the energy efficiency of manufactured housing in the region. The purpose of the Work Group was two-fold: first to advise Bonneville on the development of a manufactured housing program, and second to establish a region-wide program to acquire energy through conservation by 1991-1992.

Budget Constraints Cause a Major Setback. A few months later, early in 1987, Bonneville was faced with major agency-wide budget cuts. All programs faced scrutiny from management to meet substantial funding reductions. Some programs were even cancelled. The fledgling manufactured housing program was reduced, as were others, but not eliminated. Both the marketing effort and the proposed cost-effectiveness studies were severely constrained as were all other investigative efforts.

The Council Lends Support. The manufactured housing program received a boost when, in June 1987, the Northwest Power Planning Council issued recommendations fully supporting the program. The Council recommended that Bonneville "accelerate efforts to develop cost-effectiveness data for the manufactured housing industry to support a regular program" and "include manufactured housing in the new residential program." This vote of confidence changed the program dramatically. Bonneville's managers, wrestling with competing priorities, were given a focus and direction by the Council and from this point on the program progressed rapidly.

The Work Group's Recommendations. Later in June 1987, the Work Group met to revitalize the program. It chose Bonneville to act as the lead agency to coordinate and develop the program. Utility and manufacturer participation was encouraged, but not mandatory.

The Work Group submitted program recommendations to Bonneville which echoed the Council's directive. Innovative in its approach, the Work Group suggested the following: 1) Allow utilities the option to participate in the program and make incentive payments to the home buyer, dealer, or manufacturer on the same basis as incentives for site-built homes through the Super Good Cents (SGC) program; 2) Include manufactured housing in the Residential Construction Demonstration Project (RCDP) to determine the cost-effectiveness of ECMs and help determine efficiency standards for the region.

The RCDP/SGC Manufactured Housing Program

In August 1987, with input from the Work Group and backing from the Council, Bonneville added a study of manufactured homes to the RCDP program. The combination of demonstration, study, and marketing became known as the RCDP/SGC Manufactured Housing Program.

Scope. The expanded program was to include

1. **Construction of Homes:** Construct a representative sample of 150 homes built to MCS requirements, inspected, sited, and monitored for energy use through one heating season. Each home would be metered to determine space and water heating, and total energy use. Also included were infiltration and blower door tests to determine air leakage rates.
2. **Cost Data:** Collect the actual cost for each installed ECM from participating manufacturers; analyze and report the results.
3. **Manufacturer's Experiences Report:** Interview manufacturers participating and not participating in the RCDP and prepare a report characterizing their experiences and perceptions.
4. **Dealer Experiences Report:** Interview participating dealers and prepare a report describing their experiences.
5. **Cost-effectiveness Analysis:** Determine the incremental cost-effectiveness for each ECM.
6. **Modeling:** Develop and verify computer models to predict energy use and savings for manufactured homes.

Technical Specifications. Before homes could actually be built, it was important that the technical specifications be completed. A subgroup of the Work Group completed this effort in time to start the project.

The model for these specifications was the MCS used in the site-built industry. However, considerable work had to be done to modify the specifications to realistically accommodate manufactured homes. For example the floor and ceiling construction of manufactured homes differs from that of site-built homes. Manufactured homes have height restrictions because they are transported by truck along highways and roads from factory to site. The roof and floor cavities are space-restricted, limiting the amount of insulation that can be included. The walls are basically similar to site-built construction, and may, in fact, be a little more energy efficient due to lighter frames. Meeting the overall MCS requirement meant reducing the window area or improving the window U-factor. The latter was more costly. This trade-off became a major issue later in the development of the program.

The Work Group's technical specifications were completed in November 1987, and were referred to as the RCDP/SGC Technical Specifications (BPA 1987).

Benefits and Incentives. The RCDP/SGC Manufactured Housing Program was designed to include manufacturers, dealers, utilities, and home buyers. Under RCDP, manufacturers were offered \$2,000 to \$3,000 to voluntarily build homes that met Bonneville's Technical Specifications. In return they were required to provide cost data information on each home. The incentive level was based on the estimated cost of complying with the requirements.

Dealers were also included. Under RCDP they received \$500 for each home sold and ultimately sited in a participating SGC utility area and \$250 for each home sited in a non-SGC area (not all regional utilities chose to participate in the SGC program). Dealers were an important element in the program because they were the first to offer the SGC package to the home buyer. In addition to financial incentives, Bonneville offered dealers the power of SGC advertising through TV, radio, printed media, and at the point of sale.

Homeowners received the most benefits. First they received lower monthly heating bills through an improved insulation package. The SGC package was offered to buyers at various prices by different manufacturers because their costs varied. Some offered it at no extra cost while others charged up to \$1,500 more. If the home was sited in a participating SGC utility area, the home buyer received between \$1,000 and \$1,500. Home buyers in the coldest climate zone (including Montana and parts of Idaho) received upwards of \$4,800. This included an additional \$300 paid to the home buyer for allowing energy use monitoring of the home.

Participation. Emphasis must be placed on the voluntary participation by manufacturers, dealers, utilities, and ultimately the customer who chose to purchase the energy-efficient options. RCDP/SGC was created as a voluntary program. Not all manufacturing plants, dealers, or utilities chose to participate. In fact only eight of the seventeen (today there are eighteen) regional manufacturing plants participated in the program and only 40 of an estimated 250 regional dealers. Although there were doubts that the incentives offered through the program would be sufficient to overcome market inertia and manufacturer/dealer skepticism, the incentives proved to be more than adequate in the long run. And in the end it was the customer that moved the market toward recognition of the value of energy-efficiency in the market place.

As contract agents, the State Energy Offices of Oregon, Washington, Idaho, and Montana played an important role in implementing the program. They provided a variety of support to manufacturers, dealers, participating SGC utilities, and home buyers.

Subcontracts were established between Bonneville and Pacific Northwest Laboratory and Ecotope to collect and analyze program data. The results of these studies provided a firm foundation for the program and future activities.

Slow Progress. The proposal originally called for a one-year post-construction study of the manufactured homes. Energy use monitoring, infiltration measurements, and homeowner questionnaires were part of that effort. Bonneville put the RCDP contracts into place with the State Energy Offices in readiness for the upcoming heating season. Data collection was to be completed by the summer of 1988.

Officially the RCDP/SGC program kicked off in January 1988, but it was not until March that production was completed on the first home. Despite the cash incentives and planning, the most important players in the program, the home buyers, were not coming to the dealerships. By July only 26 homes had been sold. Early results were discouraging, and program managers were concerned that the program was too ambitious or perhaps under-funded or poorly organized.

By November it was clear that the original goal of 150 homes to be built and sited for the 1988-89 heating season would not be met. Bonneville made the decision to stay with the program however. Both the RCDP contracts with the state energy offices and the SGC advertising budgets and completion dates were extended into the next year. Data collection was extended through another heating season.

In December 1988, almost a year from the start, only half of the homes had been sold and built. Finally, as word-of-mouth advertising, growing consumer interest, and other factors came into play, the program took-off. By February 1989, just three months later, the full complement of 150 homes had been ordered and sold. The initial role of RCDP was completed.

Data collection from the 150 homes over the next heating season was the next important step. This information, along with the already collected and analyzed cost data, would be enough to define cost-effectiveness for this housing sector.

But the enthusiasm generated by RCDP/SGC continued. When the RCDP/SGC program ended many dealers were caught with orders that could not get the RCDP portion of the incentives, and many customers were turned away. Although they were no longer eligible to receive the RCDP portion of payment, they could receive the SGC-utility portion if the home was sited in a participating utility area (\$1,000, \$1,250, or \$1,500 depending on the climate zone). Manufacturers and dealers argued that this incentive was too small. But they both agreed that the program should continue in some form or another.

Transition to SGC

Both manufacturers and dealers asked Bonneville "now what?" The response was another Work Group meeting on March 30, 1989, to discuss the continuation of the RCDP/SGC. At that meeting Work Group participants discussed incentive levels and decided to continue the SGC payments through participating utilities through December 31, 1990. The following incentive levels were set:

Climate Zone I	\$2,000
Climate Zone II	\$2,500
Climate Zone III	\$3,000

SGC utilities would be allowed to divide this payment between the dealer, buyer, and manufacturer as they determined. Also, acting in good faith, Bonneville and the utilities agreed to make these payments retroactive, to cover the period from the end of the RCDP portion to the resumption of the higher level incentive under SGC.

Manufacturers and dealers agreed and the SGC program continued with the understanding that when the cost-effectiveness study was completed either the technical specifications would change, the incentive payment would change, or a combination of both would occur.

Utilities Up the Stakes

In the summer of 1990, one regional utility (a public utility district) formally decided to levy a \$2,000 hook-up fee on all inefficient homes sited in its service territory that did not meet Bonneville's technical specifications for energy efficiency. The policy went into effect on August 15th. "All" included site-built and manufactured homes. The utility board, after reviewing evidence that many new manufactured homes were being brought into its service territory that did not meet the same high requirements that had been instituted for site-built homes, decided that the additional charge was justified to offset the cost of purchasing more-expensive electric energy.

Two factors are important here. First, each regional utility has the right to operate its system in a fair, competitive, and business-like manner. This particular utility had determined that over one-third of the new electrically heated home hookups were for homes not built to its required specifications, and that these were manufactured homes. The utility decided that a \$2,000 hook-up fee on all homes (site-built and manufactured) was justified to offset its costs for adding the electrical service needed to supply each new home over its entire life (about 45 years). The utility argued that it was good utility management practice, especially because it was applicable to all new residences.

Second, under HUD's preemption clause, manufacturers believed they had the right to be exempted from regulations established by any state or local jurisdiction. However, whether or not the utility fee was included in the clause was a debatable issue. Few manufacturers would choose to give up the preemption clause, but to take the issue to court could bring into question this benefit or even put it at risk: utilities had lawyers too.

Manufactured Housing Acquisition Program

Such was the situation in the fall of 1990. It was clear to both manufacturers and utilities that they had a common interest in the life-time energy costs of a home. Thus began the final process of utility and manufacturer negotiations which led to the creation of the Manufactured-Housing Acquisition Program (MAP).

MAP was simple in concept: a contract offer by utilities to each of the 18 regional plants to build 100% of their product line to meet a single, regional energy-efficiency requirement.

Negotiations began with Bonneville representing the regional utilities and the Washington Manufactured Housing Association representing the manufacturers. Two significant questions had to be answered: 1) What would the technical construction specifications require of the manufacturer? and 2) What would the utilities pay for such a resource?

By this time the results of the RCDP study were nearly ready. The cost and energy use data, which had been collected and analyzed, were being readied for publication. Although these results were not published until April 1991, it was already determined that the average energy consumption could be simulated on a computer within a 5% range (BPA 1991). With validation of the computer simulation program, it was possible to accurately predict

the cost and amount of energy used or saved by a variety of ECMs under varying climate conditions. The computer simulation model played a key role in the negotiations between utilities and manufacturers.

One major item that had to be negotiated was the conservation package required to meet the MAP specifications. To simplify production, manufacturers wanted a single climate zone, unlike the previous SGC and RCDP/SGC programs which had three climate zones. The manufacturers also wanted unlimited glazing. They argued that one reason more homes had not been built and sold under the previous SGC program was because manufacturers had to limit window area in some cases to meet the efficiency requirements. Utilities agreed with them and created a single "one-size-fits-all" zone with unlimited glazing. Utilities also agreed to pay manufacturers \$2,500 for each MAP home built. The MAP specifications are presented in BPA 1992.

All of the Northwest's manufacturers have agreed that, by October of 1992, 100% of their electrically heated manufactured homes will be built to the MAP energy-efficiency guidelines which are more rigorous than the SGC requirements. These homes will use less than half the energy of standard manufactured homes and should account for additional savings of 7.5 megawatts of energy in the region annually.

Research Results

Results from the manufactured housing study conducted during the RCDP/SGC program added significantly to Bonneville's understanding of energy use in this housing sector. This data will continue to be used as manufactured housing policy evolves.

Under the RCDP/SGC program, data were collected from 150 manufactured homes purchased between January 1988 and February 1989 and monitored over the 1989-1990 heating season. The homes were triple metered to show space heat, water heat, and overall energy use. Cost data on each ECM installed was collected and analyzed and a cost-effectiveness analysis was conducted. Computer modeling was also conducted, based on the data collected, to predict energy use and savings. The results of the RCDP research are discussed below.

Heat Loss Coefficients

The nominal U_o , UA , and nominal R-values for the different types of construction are shown in Table 1.

Table 1. Nominal Insulation Levels and Heat Loss Coefficients

	<u>Uo^(a)</u>	<u>UA^(b)</u>	<u>Typical Insulation Levels</u>					<u>Glazing (Uo)</u>
			<u>Wall</u>	<u>Roof</u>	<u>Floor</u>	<u>Door</u>		
HUD Minimum	0.126	640	R-11	R-11	R-7	R-5	0.80	
Base Home	0.096	530	R-11	R-19	R-11	R-5	0.80	
SGC/RCDP	0.074	388	R-19	R-38	R-30	R-5	0.45	
MAP	0.054	305	R-21	R-49	R-33	R-5	0.35	

(a) Uo is the Transmission Heat Loss Coefficient in Btu/hr-ft²-°F.

(b) UA is the overall heat loss coefficient in Btu/hr-°F.

HUD Minimum is the maximum allowable heat loss coefficient set forth under the FMHCSS. The Base Home is an average of the upgrade package, either already included by the manufacturer in the home as a good marketing strategy or requested by the buyer as a prudent investment in the home. The Base Home, not the HUD Minimum, represents the point from which the added costs and energy savings were measured. Relative to the Base Home, the RCDP homes represented about a 30% improvement in the basic thermal integrity.

Energy Use and Savings

Table 2 shows the average energy usage per home.

The RCDP and MAP requirements reduce space heating requirements substantially. Table 3, which uses the Base Home for reference, shows the energy savings.

Avoided Cost

In the case of Bonneville and its customers, avoided cost is 56 mills/kWh or 5.6 cents per kilowatt-hour, and represents the cost of electricity from a new coal-fired power plant in the Pacific Northwest. (All reported costs are in 1990 dollars.) Any potential resource that helps a utility system meet its electric loads at a price lower than this avoided cost is considered to be cost-effective to the region.

When comparing the acquisition of an energy resource to avoided cost, many factors must be considered: for

Table 2. Manufactured Housing Space Heating in kWh/Yr^(a)

	<u>Zone 1</u>	<u>Zone 2</u>	<u>Zone 3</u>
	<6,000 HDD	6-8,000 HDD	>8,000 HDD
HUD	13,800	20,000	23,500
Base Home	10,900	16,200	19,100
RCDP	5,600	9,200	10,900
MAP (Proposed)	4,000	7,100	8,500

(a) HDD is heating degree-days.

example the life expectancy of the resource, when the resource will become available, the energy savings, the capital cost, and maintenance and operating cost. The new manufactured housing conservation resource not only presents an energy resource far below the region's cost-effectiveness threshold of 5.6 cents/kWh, but is also very inexpensive when compared with other conservation resources.

Table 3. Annual Energy Savings for Manufactured Housing Space Heating when Compared to Base Home in kWh/Yr

	<u>Zone 1</u>	<u>Zone 2</u>	<u>Zone 3</u>
	<6,000 HDD	6-8,000 HDD	>8,000 HDD
Base Home	---	---	---
RCDP	5,300	7,000	8,200
MAP	6,900	9,100	10,600

Assuming a 45-year manufactured home lifetime and an annual discount rate of 3%, the cost of purchasing this resource at the factory was far below the regional avoided cost for new generating plants, as shown in Table 4. Given regional production rates of over 10,000 manufactured homes per year and annual energy savings of 5,300 to 8,200 kWh per RCDP/SGC home, the potential regional benefits are substantial.

Table 4. Comparison of Base Home to RCDP/SGC Home

	<u>Zone 1</u>	<u>Zone 2</u>	<u>Zone 3</u>
Cost to Utility	\$2,000	\$2,500	\$3,000
Energy Savings, kWh/year	5,300	7,000	8,200
Levelized Cost, Cents/kWh	1.54	1.46	1.49

Under MAP the utilities offered (and the manufacturers accepted) a \$2,500 flat payment for all homes produced at each plant, after agreeing on a single climate zone for the region, i.e., one technical specification for all homes no matter where they are sited. The price was negotiated based on the wholesale cost to purchase that package from

the factory. Not only were the MAP savings larger than under SGC, the levelized cost was further below the 5.6 cents per kWh avoided cost established by Bonneville.

Table 5. Comparison of Base Home to MAP Home

	<u>Zone 1</u>	<u>Zone 2</u>	<u>Zone 3</u>
Cost to Utility	\$2,500	\$2,500	\$2,500
Energy Savings, kWh/year	6,900	9,100	10,200
Levelized Cost, Cents/kWh	1.48	1.12	0.96

The weighted regional average cost per home was \$2,500 with an energy savings of 7,900 kWh for a levelized cost of 1.3 cents/kWh over the home's 45-year life.

The savings, by any measure, are impressive. And the low cost per kilowatt hour saved was enough to convince the regional utilities to support Bonneville's contract offer to the regional plants. Few resources could compete with those savings.

Conclusions

After the results of the RCDP study were revealed, utilities became aware of the significant savings that could be gained from this housing sector. They were even more impressed by the levelized cost of those savings.

The amount paid to manufacturers for each MAP home was \$2,500 for regional average energy savings of 7,900 kWh per home per year. This is equivalent to a levelized cost of 1.3 cents/kWh saved. Under the RCDP/SGC, the sales weighted average incentive paid by the utilities was about \$2,200; the energy savings were about 6,000 kWh per home per year; and the levelized cost of the savings was about 1.5 cents/kWh. By comparison electricity produced from a new coal-fired power plant in the Pacific Northwest is 5.6 cents/kWh.

The potential exists for greater savings in manufactured housing by more effective use of incentives. For example,

the retail price of the base home increased about \$3,700 to improve the home to meet the RCDP/SGC Technical Specifications. Most or all of this increase was paid for under the RCDP/SGC program through rebates. The manufacturers' wholesale cost (materials, labor, overhead, and profit), however, averaged about \$3,100 to install and deliver a RCDP/SGC home. These costs suggested to Bonneville that the same home buyer savings could be achieved at a lower program cost if the incentives were paid directly to the manufacturer.

Establishing energy conservation as a standard feature rather than an option would cut costs to the manufacturers who stock and apply those materials in normal production. This change should save money for the home buyer and the manufacturer.

In a spirit of cooperation and innovation, the regional construction standards for new manufactured homes are substantially improved with benefits for all. Manufacturers benefit from improved quality in their homes, and a potential increase in customers. Utilities benefit through cost savings to their customers and avoiding the cost of building expensive new generation plants, an effect with environmental benefits as well. Home buyers receive the most benefits of all - they avoid high utility bills and receive a quality home.

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