British Columbia Hydro
PowerSmart
High-Efficiency Motors
Profile #38, 1992

Executive Summary

Each year over 300,000 horsepower (HP) of 3-phase integral electric motors are purchased by British Columbia Hydro (BCH) customers, including standard and high-efficiency motors. The goal of the High-Efficiency Motors Program has been to transform the market in the province and to make sure that most if not all of these motor sales are high-efficiency motors. Given the low electricity costs in British Columbia, many B.C. Hydro customers have opted to pay the low initial costs of standard efficiency motors despite the lifecycle benefits of high-efficiency motors. Overcoming this barrier, has been the essence of the High-Efficiency Motors Program.

B.C. Hydro launched the Energy-Efficient Motors Program in 1988 and in 1989 it became a full-scale Power Smart initiative with rebates for participating customers. In 1990, a vendor incentive was added to further encourage stocking and sales of high-efficiency motors. In 1990, a Buy-Back option was added to accelerate the change out of the installed stock of standard motors. For participants in the program incentives are offered in the form of rebates of $293 ($350 Canadian) per kW saved. Another $59/kW ($70 Canadian) is offered to distributors under the vendor incentive.

One of the difficulties of implementing a motors program is that motors are sold in three ways, through direct sales, whereby the motor manufacturers' representatives contact and sell large orders to industries directly; through Original Equipment Manufacturers (OEMs) which embed motors in equipment; and by local distributors, or what are commonly called vendors in this profile. B.C. Hydro has been successful at implementing change in all three areas, with particular success in swaying the incorporation of high-efficiency motors in OEM equipment, a most difficult challenge. Six of the ten major motor vendors in the province sell motors to OEMs and these large vendors suggest that 18% of their sales volume is to OEMs, and 63% of that is high-efficiency motors.

The total costs for the program over the 3.25 years in study are $4,080,800. As of December 1991 the program resulted in total annual savings of 47.0 GWh. Note that the program's annual savings have been increasing from 11 GWh in 1989 to 15 GWh in 1990 to 21 GWh in 1991. In terms of peak capacity BCH estimates that the program's net savings are 6.6 MW.But perhaps more important than the overall savings and costs, is the basic fact that the High-Efficiency Motors Program has effectively transformed the motors market in British Columbia. As this profile documents, the province has experienced a dramatic turnaround in the percentage of high-efficiency motors sold in a mere four years. This has clearly been a function of increased awareness and properly calculated incentives strategically placed for maximum effectiveness.

High-Efficiency Motors Program

Utility:	British Columbia Hydro, Power Smart
Sector:	Industrial
Measures:	High-efficiency motors, efficient gear speed reducers, synchronous belts.
Mechanism:	Participant and vendor rebates.
History:	Started in 1988, became a Power Smart Program in 1989.

1991 Program Data

Energy savings:	21 GWh
Lifecycle energy savings:	418.3 GWh
Peak capacity savings:	3.30 MW
Cost:	$1,817,700

Cumulative Data (1988 - 1991)

Energy savings:	47 GWh
LIfecycle energy savings:	949 GWh
Peak capacity savings:	7.49 MW
Cost:	$4,080,800

Conventions

For the entire 1992 profile series all dollar values have been adjusted to 1990 U.S. dollar levels unless otherwise specified. Inflation and exchange rates were derived from the U.S. Department of Labor's Consumer Price Index and the International Monetary Fund's International Financial Statistics Yearbook: 1991.

The Results Center uses three conventions for presenting program savings. **Annual savings** refer to the annualized value of increments of energy and capacity installed in a given year, or what might be best described as the first full-year effect of the measures installed in a given year. **Cumulative savings** represent the savings in a given year for all measures installed to date. **Lifecycle savings** are calculated by multiplying the annual savings by the assumed average measure lifetime. **Caution:** cumulative and lifecycle savings are theoretical values that usually represent only the technical measure lifetimes and are not adjusted for attrition unless specifically stated.

Utility Overview

British Columbia Hydro and Power Authority (referred to as B.C. Hydro and BCH in this profile) provides electric service to 1.3 million customers in the province of British Columbia in Canada, a province just north of the State of Washington along Canada's Pacific coast. Its service area includes 92% of British Columbia's population, with a concentration in the Vancouver area. Although the vast majority of B.C. Hydro's customers are residential customers, residential sales represented only 26% of the electricity B.C. Hydro sold in 1991. The largest consumer was the "transmission" sector (or large industrial sector) which accounted for 34% of electricity sold in 1991. What BCH calls the "general distribution" sector (customers with demands of 35 kW and higher) received 30%. The remainder went to electricity trade and other destinations.

Electricity sales volume increased in 1991 to 43,991 GWh. Average annual kWh use for residential customers and small commercial customers increased in 1991, while average consumption for large industrial customers decreased from 1990 to 1991.

Hydroelectric plants generate most of B.C. Hydro's electricity. Only 5% is generated by other sources. B.C. Hydro predicted, in its 1991 Electricity Plan, that no new generation facilities would be required until 2005. In that plan, B.C. Hydro committed to make full use of its existing facilities and to fully develop other resource options prior to developing new hydro generation projects. These other resource options include: Power Smart, B.C. Hydro's DSM initiative discussed in the next section; coordination and purchases; a capacity enhancement program called "Resource Smart;" and private sector generation. [R#1,2]

B.C. HYDRO 1991 STATISTICS

Number of Customers	1,289,590	
Energy Sales	43,991	GWh
Energy Sales Revenue	$1.636	billion
Winter Peak Demand	8,122	MW
Generating Capacity	10,466	MW
Reserve Margin	28.86%	
Average Electric Rates		
Residential	4.62	¢/kWh
General	4.05	¢/kWh
Transmission	2.48	¢/kWh

[R#1]

Utility DSM Overview

B.C. Hydro launched its Power Smart initiative in March of 1989 with the objective of obtaining a 2,400 GWh load reduction over ten years through the implementation of residential, commercial, and industrial DSM programs. The initiative received much initial success, and B.C. Hydro expanded Power Smart's goal to a 5,600 GWh reduction by the year 2010. Power Smart, Inc., a wholly-owned subsidiary of B.C. Hydro, was established in 1990 to provide DSM services to other utilities in Canada and around the world. As of September 1992, Power Smart Inc. served 19 Canadian members (including both utilities and agencies), as well as member utilities in the Caribbean, Mexico, Czechoslovakia, and the United States with DSM program design and comprehensive marketing assistance.[R#8]

CURRENT B.C. HYDRO DSM PROGRAMS

RESIDENTIAL
New Home Program
Home Improvement
Refrigerator Efficiency
Refrigerator Buy-Back
Electric to Gas Hot Water
Power Smart Water Heaters
Education Program
Non Integrated Areas

COMMERCIAL
Energy-Efficient Lighting
New Building Design
Water Heating Conversion Pilot
Building Improvements

INDUSTRIAL

High-Efficiency Motors Program
Efficient Compressed Air
New Plant Design
Efficient Roadway Lighting
Bonus Partners
Efficient Fans
Power Plays
Pumping Profits

Utility DSM Overview Table	Annual DSM Expenditure (x1000)	Annual Energy Savings (GWh)
1989	$8,457	52
1990	$30,082	195
1991	$48,714	452

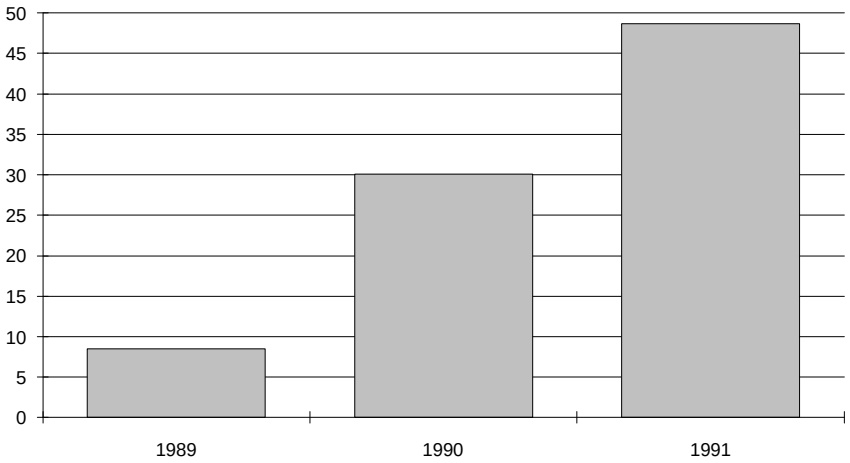
[R#3]

The initiative at B.C. Hydro was launched with a handful of programs and has included as many as 27 Power Smart programs operating concurrently. As of March 1992, these programs had generated 724 GWh in savings.[R#3] One of the major reasons for Power Smart's success is an exceptionally high customer awareness level exceeding 90%. One of B.C. Hydro's most successful programs aimed at increasing customer awareness was "Power Smart Month." The program, first conducted in 1990, consisted of a month of energy awareness promotion culminating on "Power Smart Night" when customers were encouraged to turn off all unnecessary lights. When the program was repeated in October of 1991, B.C. Hydro estimates that its customers saved 244 MWh on Power Smart Night alone.

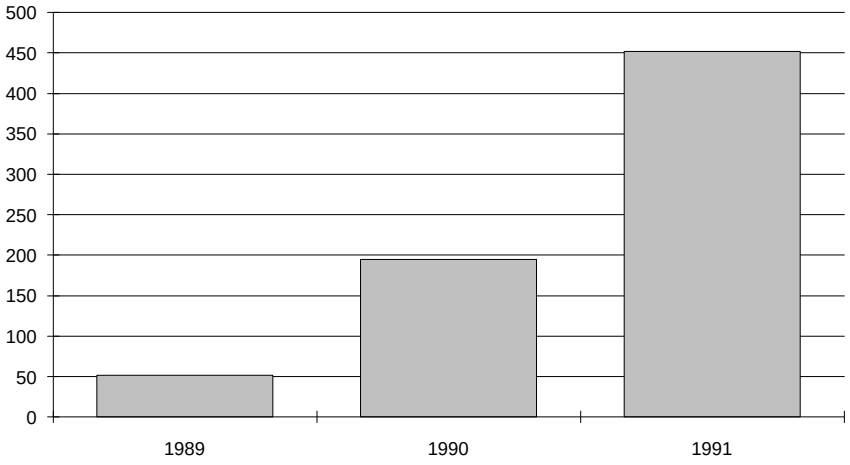
In 1992 B.C. Hydro operated eight residential DSM programs. These programs included two programs pertaining to refrigerators (see The Results Center Profile #10), two programs pertaining to hot water use, an energy audit program, a new home construction program, an education-oriented program, and a program aimed specifically at reducing load in those areas not served by main electric transmission lines.

Commercial sector DSM programs offered in 1992 included a lighting rebate program, building improvement and new construction programs, and several other programs. For industrial customers, B.C. Hydro offered a number of rebates, education, and incentive-based programs, including the very successful high-efficiency motors program discussed in this profile, fans and pumps programs, an efficient roadway lighting project, new plant design assistance, compressed air program, and two customer idea programs.[R#4,5]

ANNUAL DSM EXPENDITURE ($1,000,000)



ANNUAL ENERGY SAVINGS (GWH)



Program Overview

British Columbia Hydro has over 22,000 industrial customers which use 17,000 GWh of utility-generated electricity each year, 90% of which is used to power motor systems. Power Smart staff estimate that on average high-efficiency motors use 3% less electricity than standard efficiency motors (varying with motor size), representing a potential to save over 500 GWh per year in the province.

Each year over 300,000 horsepower (HP) of integral electric motors are purchased by B.C. Hydro customers. They are segmented into two types: standard and high-efficiency motors. This segmentation provides customers with a fundamental choice between low capital costs through the purchase of standard efficiency motors or low lifecycle costs through the purchase of high-efficiency motors. Since the costs of electricity in Canada have been historically low, many customers have opted to minimize initial costs and to buy standard efficiency motors. Overcoming this barrier has been a fundamental challenge for Power Smart.

B.C. Hydro launched the Energy-Efficient Motors Program in June of 1988, before the Power Smart initiative began. In July 1989, when Power Smart was launched, it became a full-scale program and was renamed the Power Smart High-Efficiency Motors Program. In July 1990, a vendor incentive was added to further encourage stocking and sales of high-efficiency motors. In October 1990, a Buy-Back option was added, to accelerate the change out of the installed stock of standard motors. Finally, B.C. Hydro offers incentives for additional drivepower improvements such as synchronous belts, efficient gear reducers, and adjustable speed drives for fan and pump applications.

For participants in the program incentives are offered in the form of rebates of $293 per kW saved ($350 Canadian). Another 20% ($59/kW, $70 Canadian) is offered to distributors under the vendor incentive. These incentives have not only resulted in energy and capacity savings, but have also been instrumental in transforming the motor market in British Columbia. Much of this profile will focus on this market transformation as high-efficiency motors have taken root in the province.

MARKETING

Marketing the High-Efficiency Motors Program has been effectively accomplished in a number of ways. Participants find out about the program from B.C. Hydro staff and from motor vendors. Large industrial customers are contacted routinely by BCH marketing representatives, and a specialist representing the motors program calls on all of the motor vendors and rewind shops regularly to ensure their familiarity with the operation and benefits of the program. By incorporating a vendor incentive in the program, BCH has found that vendors use the BCH rebate and other program supplied information as sales tools. They have taken a critical role in educating their customers about the advantages of high-efficiency motors and assisting them in participating in the rebate procedure. The database of energy-efficient motors and their rebated levels is distributed biannually to vendors and manufacturers and shows the rebate amount for each qualifying motor available.

DELIVERY

One of the difficulties of implementing a motors program is that motors are typically sold in three ways. They are sold through direct sales, whereby the motor manufacturers' representatives contact industries directly. Second, and perhaps the most complex arrangement, is that Original Equipment Manufacturers (OEMs) embed motors in equipment. For example, compressors are sold that incorporate motors within their housings. Third, motors are sold by local distributors, or what are called vendors in this profile.

Direct Sales Very often a purchase order for a large company is awarded to the manufacturer. One, two, or five year supply agreements are set up.[R#7] Customer rebates are paid for these purchases, though the manufacturers are not eligible for the vendor rebate. (Vendor rebates are only paid to those companies that stock product on the shelves for B.C. industry.) In 1990 22% of rebated horsepower went to participants who bought motors through direct sales. This can be compared to rebated horsepower in 1990 for OEM sales (24%) and vendor sales (54%).

Original Equipment Manufacturers OEMs, or original equipment manufacturers, refers to those manufacturers who incorporate a motor into packaged equipment that would then be sold to end-users. In contrast to the situations in other provinces, and certainly in other states, OEM production in British Columbia is aimed primarily at British Columbia markets, and so customers of OEMs in B.C. are eligible to apply for BCH rebates. There are no incentives for OEM manufacturers.

Unlike the track records in many other areas where it has been hard to get high-efficiency motors into OEM equipment, the results in British Columbia have been impressive. Six of the ten major motor vendors in the province sell motors to OEMs, and each one sells high-efficiency motors. These large vendors suggest that 18% of their volume is to OEMs, and of that 63% of the sales to OEMs is high-efficiency motors. This has been spurred by customer demand. Three-quarters of participants who buy equipment from manufacturers in the province claim they always specify OEM high-efficiency motors.

Local distribution channels While BCH has made impressive progress in transforming the OEM market, clearly the most effective transformation has occurred in the local motor distribution networks. The top ten vendors in the province sell 80% of the motors in this channel. Another 100 vendors make up the balance of the distributor sales. These are the primary avenues for participant and vendor rebates. The following chart shows that the motors program has been quite successful in stimulating a shift to high-efficiency motors through each of these three sales channels, but has been particularly effective in transforming sales through vendors.

1990 Motor Sales by Channel	High Efficiency Motors (% of Total Market)	Standard Motors (% of Total Market)	Total Percent of Market
Direct Sales	9%	13%	22%
Original Equipment Manufacturers	10%	14%	24%
Distributors	32%	22%	54%
Total	51%	49%	100%

The High-Efficiency Motors Program currently has four primary components: educational efforts, the participant rebate, the vendor incentive, and the buy-back option which has been recommended to be discontinued. In addition, the program's management is working to support minimum efficiency legislation. The program's "exit strategy" depends on effective legislation of the product. The High-Efficiency Motors program's rebates drive the market acceptance. With enough shift in the market, regulation is relatively painless. BCH is also working with the Canadian Standards Association to assist in the development of effective standards.

Educational Efforts The investigative and educational groundwork for this program began 15 years ago. In 1975 B.C. Hydro initiated its Energy Conservation Division to encourage all of its customers to utilize energy-efficient products. In 1977 an engineer was hired to specifically work on an Industrial Electric Program. By the early 1980s, BCH had its first motors database, highlighting efficiency levels; a travelling "Energy Bus" which had motor demonstrations; supported energy audits in plants; and was running a series of seminars on motors, adjustable speed drives (ASDs) and drivepower equipment. One problem remained: after over eight years of promotion many customers wanted to purchase high-efficiency motors, but most of the province's vendors didn't stock high-efficiency motors and could only supply them on a 6-8 week lead time, which in many cases was beyond the purchaser's time frame. Thus the educational component needed to be coupled with cash incentives to stimulate the market.[R#6]

The Participant Rebate The participant rebate is the fundamental driver of the program and has been in place since the program's inception in 1988. Initially customers were offered $334/kW ($400 Canadian) for the purchase of high-efficiency motors. In 1992 the rebate level was reduced to $293/kW saved ($350 Canadian). For a typical 20 horsepower (hp) motor this translates into a rebate of approximately $200. (See representative rebate list table for 20 horsepower motors.) In 1993 additional decreases are planned to reduce the rebate by up to 50%.[R#7]

The Vendor Incentive A common barrier to the adoption of high and premium efficiency motors is that vendors are unable to carry a full line of both standard and high-efficiency motors due to their costs and the sheer number of permutations of motor sizes, speeds, enclosures, and frame types. Thus influencing this critical channel is key to market transformation in British Columbia.

The vendor incentive was introduced as a pilot in July of 1990. This incentive is available to B.C.-based distributors only and has been effective in moving regional motors distributors to carrying a significant inventory of high-efficiency motors. Since motors burnout unexpectedly, the success of the program depends in part on the inventory of motors in distributor stock. The program has been successful at "flipping" the ratio of high-efficiency motors to standard motors so that now vendors routinely recommend and stock efficient motors, and customers have become aware of their benefits and generally request them.

The Buy-Back Option The Buy-Back Option, also known as the "trade-up" option, was introduced as a pilot in October 1990 to stimulate early retirement and replacement of standard efficiency motors with high-efficiency motors and is based on the same incentive payment schedule plus 50%, for both participants and vendors. While program participants claim to be using this option quite a bit, BCH records indicate that the option is basically underutilized. The Buy-Back option has involved only 6% of the horsepower rebated since its inception and at the time of this writing accounted for about 10% of the horsepower that is promoted by the program in 1992.[R#7]

The buy-back option will be phased out in January 1993 for a number of reasons. First, few operable motors have been replaced as a result of the program. When swapping out an operable motor, a consumer faces not the incremental cost of a high-efficiency motor (which the buy-back rebate reflects), but the entire cost of a high-efficiency motor, typically on the order of $45-50/horsepower. Second, offering incentives for swapping out operable motors or those that burn out and are quickly replaced by motors in industries' inventories, may have a negative effect on the rewind market. When a motor burns out, often a replacement motor in inventory is installed, and the burned out motor is sent to a rewind shop. By buying this motor back, BCH does not receive any energy savings for the motor since its load has already been replaced. If BCH bought every low efficiency motor that could be potentially rewound and returned to service, it could drive the price of rewound and used motors up from $20/hp to $25/hp, as demand would outstrip supply, while the cost of new high-efficiency motors is on the order of $45-50/hp.

Thus Power Smart has instead focused on supporting the motor rewinding business working closely with the Electrical Service Apparatus Association (EASA) to develop and promote quality and thus high-efficiency rewinds. While no cash incentives have been paid, BCH has taken its support of the rewinding market seriously as it realizes that in order to maintain ongoing efficiency savings, the rewind market must perform quality rewind work for both standard and high-efficiency motors. One way that BCH has supported the rewind market is to be very forthright in explaining to motor customers that rewinding high-efficiency motors bears a cost premium. Customers must be aware this premium and be prepared to pay for this to the rewind shops.

MEASURES INSTALLED

High-efficiency motors are not offered in every motor size, configuration (type of enclosure), and RPM (revolutions per minute) option. Some motors are not made in high-efficiency models and others simply cannot be stocked given limited demand. Within the class of 1,800 RPM TEFC (totally-

B.C HYDRO SAMPLE REBATE AMOUNTS: PARTIAL LISTING

Totally Enclosed Fan-Cooled 3 Phase Motors -- 20 HP, 1800 RPM			
Qualifying Efficiency	Manufacturer	Description	Rebate (Can$)
94.3	Magnetek	E Plus III	$317
94.0	US Motor / Leroy Somer	TCE / TE	$299
93.9	GE	Premium Eff. KS	$293
93.7	Toshiba	EQP III	$281
93.6	Reliance Electric	XE - Premium Eff.	$275
93.0	Westinghouse	Optim - HE	$257
93.2	Siemens	PE - 21 Plus	$251
93.1	Baldor	Super - E	$245
93.0	Teco	MAX - E1	$239
93.0	Marathon Electric	High Eff. XRI	$239
92.6	WEG	Premium High Eff.	$215
92.1	GE	High Eff. KW	$184
92.0	GEC Alsthom	Cimpak-HE	$178
91.8	Leeson Electric Motors	Wattsaver	$166
91.0	WEG	High - Efficiency	$116
91.0 Power Smart Qualifying Efficiency			
90.8	Toshiba	STD	$0
90.6	US Motor / Leroy Somer	UT	$0
90.2	Reliance Electric	E-2000 energy Eff.	$0
90.2	Teco	STD	$0
90.0	Leroy Somer	STD	$0
90.0	Marathon Electric	STD	$0
89.5	Siemens	STD	$0
89.3	Baldor	STD	$0
89.2 Base Efficiency			
88.5	GE Canada	STD K SD	$0
87.0	GEC Alsthom	STD	$0
86.5	Reliance Electric	STD	$0
86.5	Lincoln	Aluminum Frame	$0

enclosed, fan cooled) motors, however, most manufacturers have most sizes available. In British Columbia, availability at the distributor level has increased greatly in the past few years, so that time consuming special orders are no longer necessary for common sizes and configurations for high-efficiency motors.

In addition to providing incentives for high-efficiency motors, B.C. Hydro offers incentives for other drivepower improvements. BCH pays incentives of $4.20/hp ($5 Canadian) for synchronous belts or up to 50% of the costs of the belt and sheaves. Synchronous belts reduce slipping and thus improve efficiency. For efficient gear reducers over 88% efficient, BCH offers $4.18/hp saved ($5 C). For adjustable speed drives, that provide optimal efficiency for variable torque loads typical of fans, pumps, and blowers, rebates are provided for $84/hp ($100 C) up to $6,270 ($7,500 C).

STAFFING REQUIREMENTS

The BCH High-Efficiency Motors Program is run by Alex Fleming, a consultant who serves as the program manager and a technical and marketing specialist, by three person years from approximately 12 Hydro marketing representatives, and two clerks who process rebates. In addition to consultants hired to perform research studies, the program is supported by approximately 0.5 full-time equivalent for evaluation.

MONITORING

This program benefits from a two-part database that effectively monitors the motor market and participation in the program. B.C. Hydro has maintained a high-efficiency motors database for many years, detailing the efficiency and availability of high-efficiency motors in the province. A second database component, the customer/vendor database, contains all the information from the rebate forms, including the details of the rebates and the savings calculations for more than 18,000 motors promoted. Information for the customer/vendor database is tracked and updated via vendor and customer rebate applications.

One interesting aspect of the customer/vendor database is that it is used to develop "outstanding claims" reports both for participant and vendor rebates. For example, when a vendor submits a claim, money is set aside in anticipation that the participant will submit a claim in the next few months, and vice verca.

It was expected that there would be considerable overlap between vendor and participant claims, and that as such the program would receive claims from both sides of the transaction. However, in a departure from what was expected, often matching claims are not submitted for various reasons. "In fact the lack of overlap was startling" to program evaluators. Further investigation, however, revealed that this "problem" was mainly a timing issue. In many cases the vendor submitted a rebate application immediately while participants' claims have tended to lag behind significantly, even spilling over into the next year. BCH then instituted a cutoff point after which claims cannot be submitted. (Since the program's inception in 1988 the program has been run in five different phases. Rebate applications are due within 60 days of the end of each phase.) Approximately 20% of the incentive budget has gone unclaimed.[R#7]

EVALUATION

The program had a preliminary process review in April 1990, and a financial audit in April 1991. The evaluation discussed below took advantage of each of these reports as well as a variety of research commissioned by Power Smart during the first three years of the program.

Much of this profile was drafted using the B.C. Hydro evaluation of the program conducted between November 1991 and the end of November 1992. The evaluation focused on determining customer and trade ally response to the program, evaluating the potential market size and high-efficiency motor penetration, and determining the total energy savings and cost effectiveness of the program.

Process Evaluation Findings: The methodology for the process evaluation (conducted in February of 1991) was based on a survey of 93 of the top 120 industrial participants. A survey of B.C.-based vendors which covered all large vendors was also conducted at that time. Program staff were interviewed, and all previous program research efforts were utilized. (Given the high penetration rates established by the program, B.C. Hydro elected not to conduct a nonparticipant survey which can often reveal key barriers to nonparticipation.)

The program's high penetration rate indicates that the program has addressed the potential barriers to participation of product awareness, product availability, and customer payback. Satisfaction with the program is high among both motor purchasers and vendors. The ratio of high-efficiency motor sales to standard motor sales has increased dramatically in the province, due to increased customer demand influenced by the participant rebate, and increased inventory levels influenced by the vendor incentive. B.C.-based distributors reported that 73% of their motor sales were high-efficiency. The Buy-Back option has not been used extensively, and represents a large expenditure without significant incremental gain.

Market Evaluation Findings: Before the program began, high-efficiency motor market share in B.C. was estimated to be around 3% of the total market. Data for 1990 indicates that market share had increased to 50%, but significant gains can still be made in each channel of distribution. Evidence indicates that since 1990 the ratio of high-efficiency to standard motors bought in the province has increased to over 60%. Research is ongoing to provide this estimate.

Impact Evaluation Findings: Over the first 3.25 years the program reported cumulative gross savings of 63

GWh and 9.26 MW, and total costs of $4,080,800. Program activity is reported in terms of number of horsepower rebated, which is converted to kilowatt-hour savings by first converting to kilowatts (using a .746 conversion factor) then multiplying by the hours of use, while factoring in the delta between standard and high-efficiency motors.

Based on the evaluation and compared to the original program estimates, the average motor loading was increased from 75% to 79% (affecting the efficiency of the motors) and the average hours of operation was decreased to 6,332 hours per year based on surveys. Adjustments were also made for free ridership and free drivership, resulting in revised savings of 47 GWh and 7.5 MW, a reduction of 25% from the originally-reported figures. B.C. Hydro found, that on average high-efficiency motors use 3.3% less electricity than their standard efficiency counterparts.

B.C. Hydro also considered the interactive effects which could cause double counting of savings, or simply overstated savings. Adjustable speed drives (ASDs), for instance, can save a great deal of energy by matching the speed of the motor with its load at a given time. When used in conjunction with high-efficiency motors, the apparent savings for the motor are overstated. This interactive effect can downsize the savings and thus decrease the program's cost effectiveness. B.C. Hydro found in its participant survey that 11.4% of the rebated horsepower was operating with ASDs with greatest use among the pulp and paper mills. B.C. Hydro claims that the interactive effect with ASDs has not been quantified and thus does not derate savings to compensate for this interactive effect. Similarly, synchronous belts can increase efficiency and thus derate the potential savings for motors. Of the 93 participants surveyed, 29 responded that they use synchronous belts on 3.2% of their rebated horsepower.

DATA QUALITY

The data quality for this profile is quite high, as B.C. Hydro and Power Smart have been thorough and apparently quite conservative in its evaluation of savings in particular. Note that the savings presented represent program activity between the fourth quarter of 1988 and the end of 1991. (Additional "raw" data is available for the first ten months of 1992 but is not presented herein.)

Several complex analyses provide the foundation for the savings estimates in this profile. Detailed appendices in the latest evaluation provide information on project scoping, a B.C. vendor survey, a participant survey analysis, database analysis, manufacturers' survey, market evaluation, impact summary, and other research. B.C. Hydro has taken seriously the fact that more analysis has to be done on the market transformation of the motor market, and how to best leverage change through incentives to participants and vendors which can be graduated over time to reflect market change.

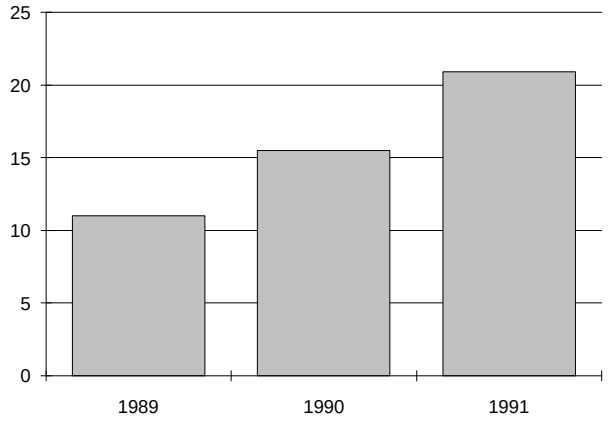
One of the reasons that B.C. Hydro has spent so much time on research and development of the motors program is that motors and drive trains, what experts refer to as "drivepower," constitutes a highly complex field. There are literally thousands of permutations of types and sizes of motors, not to mention their applications in all types of industries. This makes motor programs complex and B.C. Hydro has certainly risen to the task of careful market analysis and program impact evaluation.

Finally, all dollars in this profile, unless specifically stated, are in 1990 U.S. dollars. Where appropriate, for instance for rebate per kilowatt levels, both U.S. 1990$ and Canadian dollars are presented and 1991 Canadian dollars are assumed to be the basis for the conversions using a 0.836 conversion factor.

Program Savings

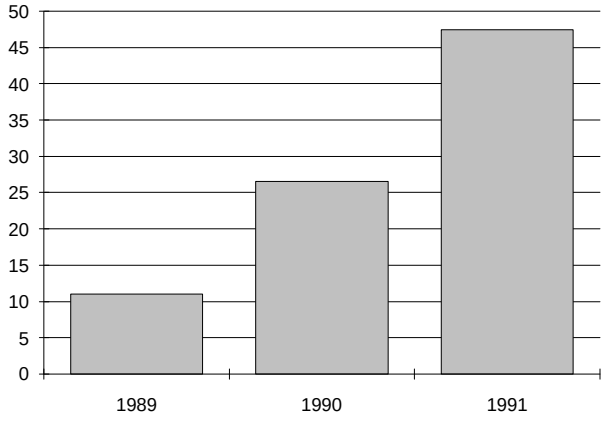
Savings Overview Table	Annual Energy Savings (MWh)	Cumulative Energy Savings (MWh)	Lifecycle Energy Savings (MWh)	Annual Peak Capacity Savings (MW)	Cumulative Peak Capacity Savings (MW)
1989	11,000	11,000	219,991	1.74	1.74
1990	15,512	26,511	310,231	2.45	4.19
1991	20,916	47,427	418,310	3.30	7.49
Total	47,427	84,937	948,532	7.49	

ANNUAL ENERGY SAVINGS (GWH)

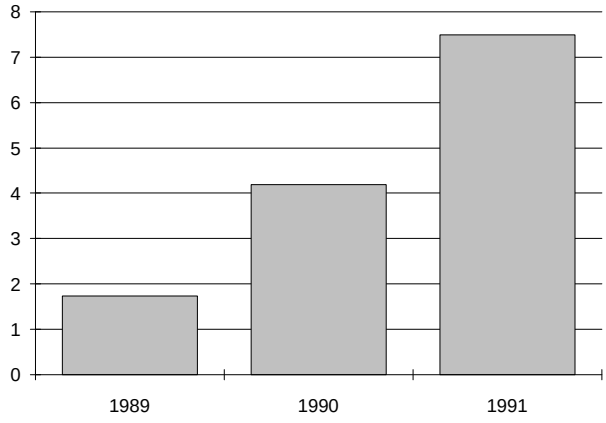


ANNUAL PEAK CAPACITY SAVINGS (MW)

CUMULATIVE ENERGY SAVINGS (GWH)



CUMULATIVE PEAK CAPACITY SAVINGS (MW)



As a result of the impact evaluation which led to changes in the assumptions used to calculate total program savings, BCH staff determined "gross evaluated savings" which are presented in this profile. To date the program has resulted in total annual savings of 47,426,000 kWh, and total cumulative energy savings of 85 GWh. Note that the program's annual savings have been increasing from 11 GWh in 1989 to 15 GWh in 1990 to 21 GWh in 1991. In terms of lifecycle savings, the program has resulted in savings of 940 GWh.

If all the high-efficiency motors put in service as a result of the program operated at the same time, then capacity savings for the program to date would be 7.5 MW. Of the high-efficiency motors which received participant rebates in 1991, 88% of the horsepower was reported to be in use during the BCH system peak (6-8pm, winter weekdays). BCH load forecasting assumes 86.6% of the total industrial load is operated during this period. Pulp and paper mills, for example, when surveyed indicated that they run their motors, inclusive of their high-efficiency motors, 97.6% of the time during BCH's peak period. For wood products industries the percentage is 87.7%. Thus BCH determined the program's net savings (reported as "evaluated gross savings") to be 6.6 MW.

PARTICIPATION RATES

Since the inception of the motor program 737 customers have received 3,153 rebates for 535,339 HP of motors. This includes 511,085 hp through customer rebates and vendor rebates, and 24,254 hp through the Buy-Back option.[R#12] Clearly the program's participation is skewed towards two industrial groups: wood products and pulp and paper. In fact the top 20 industrial groups (based on Standard Industrial Code (SIC) classification) account for 99% of the rebated horsepower, and the top five industrial classifications account for 90% of the rebated horsepower.

1991 Customers Serviced Table	Total Horsepower Rebated	Rebate Mix	Number of Participants
Pulp and Paper	35,000	33.1%	24
Wood Products	41,200	39.0%	41
Mines	4,100	3.9%	9
Chemicals	4,200	4.0%	8
Refineries	700	0.7%	3
Institutions	600	0.6%	12
Other	19,900	18.8%	366
Total	105,700	100%	463

Motor Sales in B.C. (in Horsepower)	B.C. Motor Market	High Efficiency Motor Market	High Efficiency Motors -- Total Percent of Market
Q4/1988	91,300	3,196	3.5%
1989	427,073	137,412	32.2%
1990	346,445	178,285	51.5%
1991	346,445	220,514	63.7%
Total	1,211,263	539,407	44.5%

In 1991, 463 customers were rebated for 105,700 HP of which 39%, in terms of horsepower rebated, were wood products companies, followed by the pulp and paper industry with 33.1%. While these types of companies were awarded the lion's share of the rebated horsepower, they accounted for only 65 of the program's participants.

For the purposes of providing comparative information between Results Center profiles, simple participation is based on the total number of customers participating (737) as a percentage of the total industrial base (approximately 22,000 industrial customers), for a participation rate of 3.35%. A more accurate representation, however, is presented as the percent of the horsepower of new motors purchased that are high, versus standard, efficiency. This is presented in the table above and represents "participation" province-wide in the purchase of high-efficiency motors of 51% by 1990 and 64% by 1991.

Finally, commercial customers are also provided incentives for their purchases of energy-efficient motors. For replacement motors, the High-Efficiency Motors program is used, though commercial accounts make up a small fraction of total program activity. For new construction, high-efficiency motors are rewarded through the New Building Design Program.

MEASURE LIFETIME

Expected motor lifetimes range from 6 years for small motors to over 35 years, including first life and four rewinds for large motors. While surveys suggest a weighted average technical life is 29 years, B.C. Hydro assumes an effective lifetime of 20 years due to early swapouts, obsolescence, and plant closures. This is used for both the lifecycle energy savings presented in this section and for the cost of saved energy presented in the next section.

GOALS AND PROJECTED SAVINGS

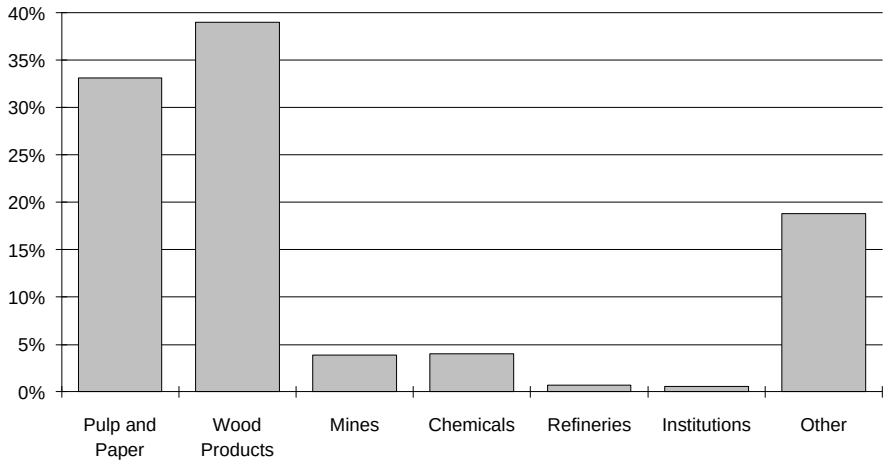
B.C. Hydro presents the program's goals for Phase 1 of the program (October 1, 1988 - September 30, 1990) and for Phase 2 (October 1, 1990 to the present). Each Phase contains long term projections.

In Phase 1, B.C. Hydro sought to induce large industrial customers to change their motor buying habits from the purchase of standard to high-efficiency motors. Second the program's goals were to obtain energy savings of 13 GWh in 1989/90, 26 GWh in 1990/91, 370 GWh by the year 2009.

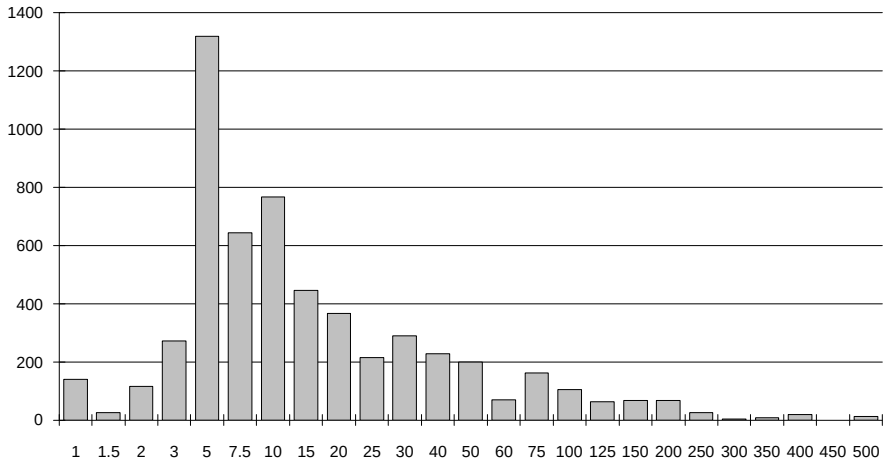
In Phase 2 B.C. Hydro aimed to "flip" the high-efficiency motor market by 1993/94 by reaching a target of 80% high-efficiency motors sales mix for 1-200 HP motors and to achieve energy savings of 100 GWh by the year 1993 , 400 GWh by the year 2000, and 1000 GWh by the year 2010. (Note that this later figure represents the full technical potential of the program. Program planners have derated this goal to 750 GWh.) BCH anticipates that legislation for T-frame motors will be in place by 1994.[R#7]

Based on reported activity the program has achieved the GWh goals to date and is well on the way to achieving the sales mix target by 1993/94. Survey results suggest that the behavioral goal of changing buying habits is also being met.

PERCENT OF TOTAL REBATED HORSEPOWER



NUMBER OF REBATED MOTORS BY SIZE



Cost of the Program

Costs Overview Table	Incentives (x1000)	Administration (x1000)	Total Program Cost (x1000)
Q4/1988		$108.6	$108.6
1989	$121.5	$795.5	$916.9
1990	$1,113.0	$124.5	$1,237.6
1991	$866.8	$950.9	$1,817.7
Total	$2,101.3	$1,870.9	$4,080.8

The total costs for the program over the 3.25 years in study are $4,080,800, including portions spent each year on administration, overhead, and research that was not directly related to energy savings or incentives. In the first quarter of 1988 the program cost $109,000, then the cost grew to just under a million dollars in 1989 ($917,000), then to $1.238 million in 1990, then to $1.818 million in 1991.

COST EFFECTIVENESS

B.C. Hydro has found the motors program to be cost effective. Its calculations of the program using the total resource cost test (TRC) was 1.05 ¢/kWh compared to its avoided cost of 3.46 cents/kWh (both expressed as 1989 Canadian dollars). The benefit/cost ratio was calculated to be 3.3.[R#6] In terms of capacity cost and assuming BCH's average system load factor, the program has resulted in a utility cost per kW (gross) of $533.

The Results Center calculates the cost of saved energy, based on a 3-9% real discount rate of less than one cent per kWh.

FREE RIDERSHIP

Free riders for the program were estimated to be equal to 9.1% of reported horsepower. Free drivership, those customers who installed high-efficiency motors in the absence of financial incentives but as a result of the program, were estimated to be as high as 23% of reported horsepower, but BCH decided to use an 11.5% value pending further research.

All rebates paid in the fourth quarter of 1988 were considered to be free riders. BCH figures that these sales would have happened anyway and that since the program was so new it is unlikely that the program's awareness building efforts and marketing contributed at all to the sale of high-efficiency motors during that period.

COST COMPONENTS

The cost overview table presents incentive costs and administration costs for the three full years of program implementation. Incentive costs of $2,101,300 have been 51% of the total, while administrative costs are 49%. Included in administrative costs are labor, materials, incentives and consulting, computer costs, printing and graphics, technical and market research, and travel expenses.

Cost of Saved Energy	Discount Rates						
	3%	4%	5%	6%	7%	8%	9%
1989	0.56	0.61	0.67	0.73	0.79	0.85	0.91
1990	0.54	0.59	0.64	0.70	0.75	0.81	0.87
1991	0.58	0.64	0.70	0.76	0.82	0.89	0.95

Environmental Benefit Statement

Marginal Power Plant	Heat Rate BTU/kWh	% Sulfur in Fuel	CO2 (lbs)	SO2 (lbs)	NOx (lbs)	TSP* (lbs)
Coal	**Uncontrolled Emissions**					
A	9,400	2.50%	183,125,000	4,345,000	878,000	88,000
B	10,000	1.20%	195,271,000	1,682,000	567,000	420,000
	Controlled Emissions					
A	9,400	2.50%	183,125,000	434,000	878,000	7,000
B	10,000	1.20%	195,271,000	168,000	567,000	28,000
C	10,000		195,271,000	1,121,000	561,000	28,000
	Atmospheric Fluidized Bed Combustion					
A	10,000	1.10%	195,271,000	514,000	280,000	140,000
B	9,400	2.50%	183,125,000	434,000	351,000	26,000
	Integrated Gasification Combined Cycle					
A	10,000	0.45%	195,271,000	346,000	56,000	140,000
B	9,010		175,650,000	125,000	42,000	8,000
Gas	**Steam**					
A	10,400		106,511,000	0	243,000	0
B	9,224		92,497,000	0	579,000	27,000
	Combined Cycle					
1. Existing	9,000		92,497,000	0	355,000	0
2. NSPS*	9,000		92,497,000	0	168,000	0
3. BACT*	9,000		92,497,000	0	23,000	0
Oil	**Steam--#6 Oil**					
A	9,840	2.00%	154,161,000	2,336,000	276,000	262,000
B	10,400	2.20%	163,504,000	2,317,000	347,000	168,000
C	10,400	1.00%	163,504,000	331,000	278,000	88,000
D	10,400	0.50%	163,504,000	972,000	347,000	53,000
	Combustion Turbine					
#2 Diesel	13,600	0.30%	204,614,000	407,000	633,000	35,000
Refuse Derived Fuel						
Conventional	15,000	0.20%	242,921,000	626,000	824,000	183,000

Avoided Emissions Based on 84,937,247 kWh Saved (1988-1991)

In addition to the traditional costs and benefits there are several hidden environmental costs of electricity use that are incurred when one considers the whole system of electrical generation from the mine-mouth to the wall outlet. These costs, which to date have been considered externalities, are real and have profound long term effects and are borne by society as a whole. Some environmental costs are beginning to be factored into utility resource planning. Because energy efficiency programs present the opportunity for utilities to avoid environmental damages, environmental considerations can be considered a benefit in addition to the direct dollar savings to customers from reduced electricity use.

The environmental benefits of energy efficiency programs can include avoided pollution of the air, the land, and the water. Because of immediate concerns about urban air quality, acid deposition, and global warming, the first step in calculating the environmental benefit of a particular DSM program focuses on avoided air pollution. Within this domain we have limited our presentation to the emission of carbon dioxide, sulfur dioxide, nitrous oxides, and particulates. (Dollar values for environmental benefits are not presented given the variety of values currently being used in various states.)

HOW TO USE THE TABLE

1. The purpose of the previous page is to allow any user of this profile to apply B.C. Hydro's level of savings from its High-Efficiency Motors Program to a particular situation. Simply move down the left-hand column to your marginal power plant type, and then read across the page to determine the values for avoided emissions that you will accrue should you implement this DSM program. Note that several generic power plants (labelled A, B, C,...) are presented which reflect differences in heat rate and fuel sulfur content.

2. All of the values for avoided emissions presented in both tables include a 10% credit for DSM savings to reflect the avoided transmission and distribution losses associated with supply-side resources.

3. Various forms of power generation create specific pollutants. Coal-fired generation, for example, creates bottom ash (a solid waste issue) and methane, while garbage-burning plants release toxic airborne emissions including dioxin and furans and solid wastes which contain an array of heavy metals. We recommend that when calculating the environmental benefit for a particular program that credit is taken for the air pollutants listed below, plus air pollutants unique to a form of marginal generation, plus key land and water pollutants for a particular form of marginal power generation.

4. All the values presented represent approximations and were drawn largely from "The Environmental Costs of Electricity" (Ottinger et al, Oceana Publications, 1990). The coefficients used in the formulas that determine the values in the tables presented are drawn from a variety of government and independent sources.

*** Acronyms used in the table**

TSP = Total Suspended Particulates
NSPS = New Source Performance Standards
BACT = Best Available Control Technology

LESSONS LEARNED

Many of the lessons learned since the program began in 1988 have been implemented in the program and are thus reflected in the prior text. B.C. Hydro has been committed to research and to follow the research and evaluations of the program with design changes to enhance the program. Several points, however, provide insights to key conceptual lessons learned to date.

• Determining the appropriate rebate levels is a challenging and dynamic task. As customer awareness increases, rebate levels can be decreased. B.C. Hydro found that reviews of rebate levels need to be conducted annually by program management. BCH found that participant rebate levels should be reduced (note the change from $400/kW to $350/kW Canadian), and that its rebate dollars should be shifted away from larger and smaller motors toward medium-sized motors to allow for a better investment of program funds.

• Hydro refers to the participants' costs as the fraction of the cost premium between standard and high-efficiency motor that the customer pays. In some cases the utility found that its rebate was greater than the marginal cost between standard and high-efficiency motors, creating a negative net participant cost. While accepting such anomalies as par for the course, BCH strives to get the participant cost to the 20% level. The motor survey conducted by BCH reveals that in the absence of the rebate, customer payback ranges from nine and a half months to 22 years. With the rebates the payback range for customers goes from negative 1.1 years to 7 years.

• Determining the optimal mix between participant rebate dollars and vendor incentive dollars is a challenging and dynamic task. Note that BCH adjusted the vendor incentive level proportionately with the participant rebate; the vendor incentive is 20% of the participant rebate and fell from $80/kW to $70/kW Canadian.

• Clearly, one of the outstanding elements of the program is its high degree of trade ally involvement (the vendors). B.C. Hydro believes that other industrial programs can take advantage of the high degree of contact with trade allies used in this program. Of particular note is that BCH respects the fact that trade allies, such as motor vendors and rewind shops have been in the business long before BCH got involved. Second, BCH was clear with trade allies about ramping down utility incentive levels and the planned exit strategy for the program. Thus they were told of BCH's intentions to transform the market, maintain the market with legislation, and then get out of the rebate business.[R#6,7]

Keeping a clear and consistent dialogue with trade allies has been critical to the success of the program. This allows the allies to contribute. Garnering this support, in addition to providing incentives, is based on solid face to face communication which requires at least 15,000 miles of travel per year for the marketing specialist! In addition to informal exchanges and one on one meetings, training sessions were conducted for trade allies so that they can address sophisticated customer questions like, "My power bill went up 5% this year and yet I can receive $12,000 in incentives? Who's paying whom?"[R#7]

• Working with large customers with high motor demands, what BCH calls "top down marketing." has been another critical strategy. By concentrating on large companies' purchasing policies the program has changed their purchasing standards. Not only has this resulted in the bulk of the program's savings, but it will likely affect the long term durability of high-efficiency motor purchasing practices even in the absence of rebates.

• B.C. Hydro has also worked with engineering consultants in the province to get them to change their standard specifications to high-efficiency motors.

• It has also been key for BCH to work with other Canadian utilities through Power Smart, Inc. with an ultimate eye towards federal legislation that will set standards requiring the purchase of high-efficiency motors.

• BCH has developed a sliding-scale rebate structure that promotes premium, high-efficiency motors. By focusing on the savings difference between the average standard efficiency motor sold, and the efficiency of the high-effi-

ciency motor, a premium efficiency motor gets a better rebate than a high-efficiency motor. (Often motor manufacturers offer high-efficiency motors as well as a line of premium efficiency motors that have the highest efficiency ratings.)

- Last, but certainly not least, the success of the High-Efficiency Motors Program is due in large part to the hard working and dedicated team that has seen the program from its infancy to maturity and fruition. The team has considered the less-than-obvious and has effectively resolved difficult questions to tough technical and marketing issues.

TRANSFERABILITY

Power Smart has implemented the High-Efficiency Motors Program in a number of other member utilities. The matrix below shows several utilities and presents some of the key variables in the programs incentives.

Power Smart High-Efficiency Motors Program Matrix	Customer $/kW (Can.)	Vendor $/kW (Can.)	Regional OEM $/kW (Can.)
Alberta Utilities (4)	400	N/A	N/A
B.C. Hydro	350	70	N/A
Manitoba Hydro	400	100	100
New Brunswick Power	200	40	40
Nova Scotia Power	200	40	40
West Kootenay Power	400	N/A	N/A

[R#13]

In areas where there is considerable use of motors either for industrial applications or for HVAC systems in commercial buildings, promoting high-efficiency motors is a necessary DSM activity. Motors consume an inordinate amount of energy, and though fundamentally efficient, the gains by replacing standard efficiency motors with their high-efficiency counterparts are significant.

First and foremost, getting an effective program underway and in place requires support of upper utility management. They need to clearly understand the program rationale (which requires a briefing or two on some of the technical aspects of motor use) and the program design and evaluation criteria. They also can be influential in assisting with the ultimate program goal of changing minimum efficiency standards for motors and other drivepower equipment. This legislation will secure the hold on efficient motor purchases, alleviating any concern that savings may erode if the incentives are removed.

When designing motor programs it is critical to "keep it simple", and this task is not easy considering all the various types of motors and their complex applications. BCH believes they have the most sophisticated motors program ever developed, but believes that its success is partly due to the fact that the lines of communication are simple. BCH has effectively worked with the vendors who then translate the program to their customers, the program's participants. For example, BCH sends the motors database information only to the vendors (who number about 150). The vendors then provide this information to customers. B.C. Hydro's approach with working with vendors is clearly one of the most transferable components of this program.

BC Hydro participates in a coordinated Canadian Utility Approach to the promotion of energy-efficient motors, technical standards development and legislative initiatives. A list of country-wide participants is appended.

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12. BCH, Program Results, Power Smart High-Efficiency Motors Program summary sheet, November 1992.

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Special thanks to Alex Fleming for his support and guidance throughout the development of this profile.