Beyond the Tank Wrap - Field Experience Implementing Domestic Hot Water Fuel Substitution in an Electric Utility DSM Program

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A rural Vermont electric utility has embarked on a residential DSM program which is designed to address residential space heat and domestic water heating loads primarily through control or fuel switching. Fuel switching is the primary measure by which the program is achieving high energy and demand savings. After eighteen months of full program operation, 60% of customers, for whom fuel switching was recommended, have fuel switched. This level of measure implementation appears to be attributable to the incentives and the "one stop" comprehensive service provided by the utility. The program services include energy analysis, measure cost financing, financial incentives, and complete installation arranging services.

This paper discusses a range of innovative program design elements including the simple field analysis tool which is used to conduct site-specific societal screening of retrofit options. The incentive structure is designed to minimize financial barriers to participation while securing co-payment from participants. The utility pays for the installation of the measure, and customers repay a portion of the cost to the utility on a monthly basis for a period of five years. The amount of the customer co-payment is 50% of the customer's average monthly projected savings. A formal impact evaluation of the program is planned for the second half of 1994. This paper includes a comparison of pre- and post-retrofit estimated savings based on a preliminary billing analysis.

Introduction

Fuel substitution as a DSM measure in Vermont has been previously examined by a number of authors (Raab and Cowart 1992; Hamilton, Milford and Parker 1992; Gamble and Weedall 1992). This paper discusses the implementation and preliminary findings of one utility program which incorporates fuel substitution as a major component of an overall DSM strategy.

In March of 1992, a rural Vermont electric utility, the Washington Electric Cooperative (WEC) initiated a comprehensive portfolio of DSM programs designed to capture maximum cost-effective DSM resources on the basis of societal cost-effectiveness (Total Resource Cost Test plus Externalities). To date, these programs remain the most aggressive DSM activity of any rural electric cooperative in the country. The programs were designed through a collaborative process that involved WEC management staff, elected trustees, environmental groups, and a state agency representing consumers in utility matters.

One of the unique programs developed through this process and currently in the implementation phase is WEC's Residential High Use (HU) Program. The program goals, as filed with the Vermont Public Service Board in Docket #5270 - WEC -1, are to achieve 3,490 MWH annual energy savings and 1.0 MW reduction in system peak after six years of program implementation. These values represent 6% reduction in annual energy use and 8% reduction in system peak for WEC. The planning process determined that these goals could be cost-effectively met with a program that combined fuel substitution, load control, and conservation measures to address major residential electrical end uses of electric space heat (ESH) and electric domestic hot water (EDHW). Fuel substitution represents 70% of the projected energy savings (2,443 MWh) and 88% of the projected demand reduction (.88 MW) for the program. [1]

Rural Electric Cooperative Characteristics

WEC is a rural electric cooperative serving 8,300 customers, of which 76% are metered residential customers. The customers are members of the Co-op and annually elect trustees. The significance of the Co-op's residential base is illustrated by the fact that residential electricity sales represent 63% of annual kWh sales for the WEC system.

Electric domestic water heating and electric space heating are estimated to account for 52% of the residential system peak which typically occurs on a winter evening.[2] A customer appliance saturation survey conducted by WEC in 1989 found that 49% of residential customers have electric domestic hot water and that 69% of these water heaters were not controlled to reduce the impact on system peak. The same survey indicated that 3% of customers have primary electric space heat, while 15% of customers use electric space heat as a secondary space heat source.

Given the significant impact that electric domestic water heating and electric space heating have on the WEC system, program planners developed mechanisms to acquire this DSM resource.

Program Design

The HU program is designed to cost-effectively identify DSM opportunities in the homes of customers with high electric use and achieve maximum installation rates of the measures which are determined to generate the greatest societal net benefits by offering comprehensive contract management services coupled with financial incentives.

Program Marketing. The identification of high use customers is a multi-step process in which information is gathered as necessary to qualify customers for the appropriate service. The intent of this process is to carefully select customers for whom it is likely to be cost-effective to deliver HU services. After eighteen months of implementation, this process has qualified 12.4% out of 1,009 customers served by WEC residential programs as HU customers.

The HU program is marketed in conjunction with the WEC Residential Direct Installation (DI) Program. Both programs are marketed to customers under the banner of the "Efficiency Saves" Program.

Potential program participants are generated both by customer requests and telemarketing. In either case, customer billing histories are reviewed by WEC energy specialists before scheduling the site visit. Information, gathered during a short customer phone survey at the time of scheduling in combination with the billing history, helps the energy specialist to determine if the customer is a likely candidate for high use services. The energy specialist uses a table to bracket EDHW usage based on simple variables gathered during the phone interview. This preliminary estimate of EDHW usage is used in a decision tree which identifies whether the customer is a likely HU candidate. Customers found not to be cost-effective to serve with HU services are scheduled for direct installation services through the DI program. Two of the three energy specialists provide the HU services. All of the specialists provide the DI services.

On-site Procedures. On-site, the energy specialist conducts a general electrical end use survey, including lighting use. As part of this visit, the energy specialist provides the direct installation services offered to the customers. The primary direct install measure is a wide range of compact fluorescent lamps which are installed in all cost-effective locations. The energy specialist also arranges for the installation of compact fluorescent fixtures where applicable.

The energy specialist then proceeds to conduct a survey of ESH and EDHW end uses. Information for EDHW use include measured shower flow rates, EDHW tank information including size, measured temperatures, insulation level, timer control settings (if present), and estimated ambient temperatures. Occupant usage patterns including number of showers per week per household member, duration of average shower, temperature mix, loads of laundry and other hot water uses are also surveyed.

As the information is collected, it is entered into a palmtop computer with a resident spreadsheet program. EDHW consumption algorithms in the spreadsheet calculate a refined EDHW estimate and a determination of whether the customer is a fuel substitution or control candidate is immediately made on-site. If the customer qualifies as a fuel switch candidate, the energy specialist completes the home survey by recording site conditions necessary for a fuel switch to take place, (i.e., potential location for water heater, venting strategy, fuel tank location).

If the customer does not qualify for fuel substitution, the energy specialist completes the DI service by installing EDHW conservation measures, if applicable. Additionally the energy specialist determines if a control timer would be applicable for the electric water heater. If the customer agrees to have one installed, the energy specialist arranges for the installation.

Analysis and Follow-up. When fuel switching is determined to be the recommended option, the energy specialist performs the complete cost-benefit analysis off-site. While the original program was designed with an on-site analysis component, it has been determined that the

analysis can be performed faster and with less errors if it is not performed in the home of the customer. Also, it is usually not possible to get an agreement to move ahead with the process because in many cases all of the decision-makers are not present at the time of the site visit.

If the measure passes the cost-benefit analysis, a summary is sent to the customer, including the estimated cost and savings, the offer of the utility incentives, and an economic analysis from the customer perspective. Typically, a follow-up call to the customer from the energy specialist is necessary to answer questions. If the customer wishes to proceed with fuel substitution, the customer signs an agreement attached to the summary which indicates an intention to make the improvement within 60 days. The agreement also authorizes the energy specialist to secure written bids for the measure.

Once the agreement has been obtained, the energy specialist prepares job specifications and solicits bids for the job. The energy specialist reviews the bids with the customer and with customer consent, contracts are prepared, the work is scheduled, and payment is authorized upon successful inspection by the energy specialist. The entire process requires six to eight weeks from site visit to final inspection.

Program Innovations

A number of innovations were made to increase participation as well as to simplify the process of performing cost-effectiveness screening for fuel switching.

Incentive Design

Program planners perceived three major barriers which prevent customers from implementing cost-effective fuel substitution for ESH and EDHW.

The first barrier is the necessity for the customer to research and arrange for the fuel substitution measure.

The second barrier is the need for the customer to provide capital for the improvement or to arrange for the financing.

The third barrier is the perception that the cost of the measure may be too high and that the savings are risky.

The HU program offers assistance, assurance, and incentives designed to eliminate or reduce the impact of these barriers. To combat the first barrier, the program provides contractor arranging services to qualified customers. These services include: (1) written specifications for the improvement, (2) solicitation of bids, (3) review of the bids, (4) contract preparation, (5) authorization for payment upon completion. This service performs the important function of liaison between WEC, the customer, and the contractor to insure that all parties' needs are met and that the measure is "commissioned" in a manner that will ensure the persistence of savings.

The second barrier, the need for the customer to provide capital or to arrange for financing, is eliminated because WEC pays for all first costs. The immediate removal of the capital requirement to implement the measure reduces the number of customers who "must think about it. "

The third barrier, the perceived risk of achieving energy savings, is reduced through the use of a mechanism that virtually guarantees cost savings to the customer. The mechanism is the formula by which the customer co-payment is calculated. The customer co-payment equals 50% of the estimated first year net annual savings for a period of five years. The repayment amount is limited not to exceed the actual cost of the improvement. In effect, this mechanism virtually guarantees the customer a minimum of 50% cost savings for five years. After five years, the customer receives 100% of the cost savings.

WEC provides an additional incentive for customers below poverty guidelines in the form of a waiver of the customer co-payment.

Evaluating Site-Specific Cost-Effective Measures

Special features have been built into the EDHW analysis tools used by the program which allow for site-specific conditions to determine a measure's cost-effectiveness. Table 1 provides the list of variables that are considered for each fuel substitution measure. All of these variables have been incorporated into a spreadsheet program which can be quickly run on a laptop or personal computer. The Fuel Analysis Screening Tool (FASTool) enables energy specialists to examine site specific conditions and evaluate measure cost-effectiveness.

The FASTool performs the following calculations:

1. estimates annual EDHW consumption; including use, pipe loss, and tank losses;

2. estimates measure costs based on site-specific conditions and equipment for each fuel type considered including LP gas stand alone, oil stand alone, LP gas integrated with existing boiler, oil integrated with existing boiler, kerosene, wood assisted with electric back-up, and solar assisted with electric back-up;

Table 1. Site Specific Variables Used to Determine Cost-Effectiveness for DHW Fuel Switch

Occupant Variables

Number of occupants
Number of showers and baths per week per occupant
Length of time per shower
Estimated hot and cold mix per occupant
Loads of laundry per week
Laundry temperature mix
Loads of dishes per week
Other major hot water use

Electric Water Heater Variables

Size of tank
Insulation value for tank
Average ambient temperature for tank
Age of tank
Presence of WEC control timer
Hot water temperature (measured)

Dwelling Characteristics

Shower flow rates (measured)
Hot water pipe length and location
Presence of pipe insulation
Location of existing water heater
Location for proposed retrofit
Existence of alternate fuels on-site
Fuel supplier and cost of existing fuel
Location for alternate fuel storage
Existence of usable chimneys
Location of potential power vent exhaust
Existence of alternate fuel boiler for integrated DHW

Alternate Fuel Equipment Variables

Energy factor for proposed retrofit (from Gas Appliance Manufacturer Asso. listings)

Standard values are used for the following variables based on fuel and equipment type:

Estimated life of proposed retrofit
Estimated annual maintenance cost
Estimated equipment installation cost
Estimated price of alternate fuel

3. estimates an adjusted energy factor of propane and oil fired equipment based on specific loads and recovery efficiency of the proposed measure;

4. estimates net present value of costs for 30-year study period including fuel costs, maintenance costs, equipment replacement costs, avoided equipment replacement costs;[3]

5. calculates the net present value of the net societal benefits (Total Resource Cost Test plus externalities);[4]

6. calculates customer economics and provides the analysis summary; and

7. compares alternate measures, allowing the analyst to identify and recommend the measure that results in the greatest net societal benefits.

The FASTool can allow for comparative analysis for nine competing measures including load control, DHW systems integrated with boilers, and solar assisted systems.

The incorporation of all of the variables into one spreadsheet program enables the energy specialist to reliably perform a complete analysis in 15 to 20 minutes.

Other Innovations

Persistence of Savings. In the WEC program, the heating equipment is removed from the residence as part of the measure. Electric water heater tanks are removed by the mechanical contractors. Heating elements are removed and disposed. Electric baseboard is removed and disposed. The contract with the mechanical contractor stipulates that the electrical equipment that is removed will not be used on the WEC system. This provides a high assurance in the persistence of savings to the Co-op.

Bulk Prices for Fuels and Materials. The WEC HU program has resulted in some reduced costs for fuels. One propane supplier has reduced fuel prices 10% for Co-op members. Bulk prices for equipment installations will be pursued in the near future.

Special Arrangements for Tenants. The program design includes a provision to address the issue of split incentives to make energy improvements. In rental situations, this occurs when the tenant pays the energy costs but the building owner is responsible for capital improvements to the property.

The current program design allows for flexible procedures when a tenant is a WEC customer. The program encourages the building owner to assume the co-payment responsibility. In turn, the owner can increase the rent in an amount equal to the co-payment. In this way, the customer still achieves 50% net savings and the building owner has no expense for the measure.

The program has only encountered a total of six rental situations which qualify for HU services. The financing mechanism has been declined in four cases and decisions are pending in the other cases. Even though the program incentives overcome financial and logistical barriers for fuel substitution, there are a number of other barriers which remain. For example, tenants will be resistant to participate if they perceive their period of continued residency in the unit to be short. On the other hand, the value of the new water heater may not be a sufficient incentive for the property owner to assume the ultimate responsibility for making required payments toward the water heater or to assume the risk of non-payment by the tenant. Additionally, in multi-family dwellings with central fuel storage, fuel cost-allocation may be a problem unless it is addressed by sub-metering. WEC and VEIC continue to seek ways to overcome these barriers.

Preliminary Results

Formal impact and process evaluations for this program are scheduled for the second half of 1994. Review of program tracking data provides a basis for preliminary findings provided below.

Participation

In eighteen months of program implementation, 150 HU analyses have been completed. Of the 65 customers who have been offered the incentive to fuel switch, 60% have implemented the measure. 40% of the customers who have been offered the opportunity to fuel switch have declined to participate. The percentages by type of fuel switch are presented in Table 2.

Anecdotal information suggests that a common reason for non-participation is that some customers for whom propane would have been the appropriate fuel, expressed a fear of the use of gas in their homes. Another reason often cited is that customers are “not sure of future plans” and therefore cannot make a commitment to fuel switch.

The technical feasibility for fuel switching has been very high. Only about 10% of the potential fuel switches have been eliminated due to technical problems such the absence of a feasible location for the alternate fuel water heater, oil or propane storage tanks, or lack of a feasible venting strategy. WEC policy will not allow venting of oil or propane into a flue in which exhaust gases from solid fuels such as wood or coal are vented. This has eliminated a number of possible fuel switches.

Types of Measures Installed

A summary of the fuel substitution projects completed by the WEC program appears in Table 3. 79% of the projects have been DHW only fuel switches. 15% of the fuel switches have been for both space heating and domestic hot water. 6% of the fuel switches have been space heat fuel switches. All of the electric space heating fuel switches to date have been in cases where electricity represents the primary percentage of energy use for space heating (typically greater than 8,000 kWh annually for space heat). Secondary electric space heating fuel switches (typically less than 5,000 kWh annually for space heat) have been analyzed and have passed benefit-cost screening but none have been completed.

A clear indication that the program is overcoming market barriers is given by the choice of fuel for stand alone DHW fuel switches. 55% of DHW stand alone fuel switches have been to oil. This is contrary to the market in which propane water heaters are by far the more common retrofit. (Natural gas is not available in the WEC service territory.) As the table shows, the average installed cost for the oil stand-alone water heater is $1,370. This compares to an average cost of $598 for the propane water heater.

Table 2. Summary of Customer Decisions Regarding Fuel Switching

	Primary		Secondary	
	EDHW	ESH	ESH	Total
Customers Deciding to Fuel Switch	58%	75%	0%	60%
Customers Deciding Not to Fuel Switch	42%	25%	100%	40%

Table 3. Summary of Installation Costs and Estimated Annual kWh Savings

	Installed Quantity	Percent	Average Cost	Average kWh
Domestic Hot Water Projects				
Oil DHW - Stand Alone	11	28%	$1,370	5,100
Oil Indirect Fired DHW	9	23%	$1,166	4,839
Propane DHW - Stand Alone	9	23%	$598	4,538
Propane Indirect Fired DHW	0	0%	$0	0
Solar DHW with Electric Back-up	2	5%	$4,025	5,428
Subtotal DHW Projects	31	79%		
Weighted Average			$1,258	4,882
Space Heat with Integrated DHW				
Oil Boiler & Distribution	6	15%	$6,618	13,837
Propane Boiler & Distribution	0	0%	$0	0
Space Heat Only				
Kerosene Furnace & Distribution	1	3%	$5,380	11,874
Propane Furnace & Distribution	1	3%	$2,993	8,704
Total All Projects	39	100%		
Weighted Average All Projects			$2,233	6,537

In the WEC service territory, retail oil prices average $6.52 per MMBTU. The average propane price for domestic hot water use is $13.32 per MMBTU. Over an analysis period of thirty years, the oil water heater has the least cost primarily due to this price differential, even though the oil water heater has a higher first cost, a shorter equipment life, and a higher annual maintenance budget. It would appear that the program design has been effective in motivating customers to make decisions based on long term cost-effectiveness.

Savings

Average annual kWh savings estimates from the FASTool by measure type are provided in Table 3. The average annual kWh savings for the DHW fuel switch is 4,882. For the average space heat and hot water fuel switch the average kWh reduction is 13,837. For jobs where only the space heat is fuel switched, the average annual kWh savings is 10,289.

The following preliminary findings have been calculated from a comparative billing history analysis for DHW fuel switches with eight months of billing history or greater. For a population of 10 domestic hot water fuel switches, the average annual savings was 5,232 kWh. After adjusting these savings by 397 kWh to account for the average annual savings achieved by the direct installation measures, the average savings for the DHW fuel switch was 4,835.

For the sample of 10 customers, the total average annual savings (including both fuel switch and direct installation lighting measures) represents an average reduction in the consumption of electricity of 42% per account. The highest reduction was 52% and the lowest reduction was 27%.

This can be compared to results of the evaluation conducted for the Michigan Public Service Commission (Witte, Wilder, and Kushler 1994) of a pilot program in which electric to gas water heater conversions were installed in low-income households. In this sample, average estimated annual electricity savings per participant were 5,840 kWh.

Customer Co-payment

One of the reasons for the program's high participation rate is the customer co-payment formula. For a qualifying fuel switch, the customer is required to pay 50% of the first year net annual savings for a period of five years not to exceed the entire cost to install the equipment.

The average total amount paid by the utility and the customer is provided for each type of fuel switch in Table 4. The costs in the table do not include program administration, delivery, or contract management costs.

For EDHW only fuel switches, the average customer co-payment is 72% of the total cost of the fuel switch. If one considers only EDHW fuel switches in which there was no special treatment, the average customer co-payment is 89%. Special treatment includes EDHW fuel switch co-payments, which were waived for low-income customers, and two solar DHW systems, which had a different co-payment incentive.

For ESH fuel switches, the customer contribution has been 63% for ESH only fuel switches and 55% for jobs in which both EDHW and ESH are replaced with an integrated system. For ESH, the utility has a higher share of the co-payment than for EDHW jobs. However, the avoided cost benefits are significantly higher for ESH fuel switches due to the magnitude and coincidence of the demand savings and the system peak.

Conclusions

The Washington Electric Cooperative has implemented a unique residential DSM program featuring fuel switching as a major measure to address high-use residential customers. The program is achieving high rates of implementation for recommended measures and significant per participant electrical energy reductions. Through the use of an innovative financing program that removes first cost and risk barriers and by offering comprehensive contractor arranging services, WEC has motivated customers to invest an average of $1,401 to reduce their electrical consumption. 60% of customers, for whom fuel switching has been recommended, have implemented the recommended measure.

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Endnotes

1. Measure characteristics and savings estimates for WEC programs are contained in "WEC Technical Support Document for DSM Resource Planning." All adjustments effecting savings estimates such as free riders and technical potential reductions are contained in this volume. An impact evaluation for this program is planned for Fall, 1994. One of the objectives of the evaluation is to quantify these values.

2. Load profiles for domestic water heating were developed by VEIC from a number of utility end use metering studies. The profiles were modeled to determine impact on the system peak. A full description of domestic water heating profiles is provided in "WEC Technical Support Document for DSM Planning."

3. The calculation of costs includes the cost of a replacement alternate fuel water heater at the end of the equipment life for the original fuel substitution equipment. This cost is reduced by an amount equal to the cost for the electric water heater(s) which did not have

Table 4. Customer and Utility Co-Payments for Fuel Switch Projects

Type of Fuel Switch	Average Customer Cost	Average Customer Percentage	Average Utility Cost	Average Utility Percentage
EDHW Fuel Switch (No Waivers)	$903	86%	$147	14%
All EDHW Fuel Switch	$805	64%	$453	36%
Space Heat with Integrated DHW	$4,037	61%	$2,581	39%
Space Heat Only	$2,135	51%	$2,051	49%

to be replaced. The reduction in cost is based on current prices for electric resistance storage type water heaters. It does not take into account proposed DOE rulemaking which would require the manufacture of electric water heaters of significantly higher efficiency.

4. The calculation of avoided cost benefits includes an adjustment for the environmental benefits associated with fuel substitution. The method approved by the Vermont Public Service Board for calculating the environmental benefits increases utility avoid cost benefits by 5%. The VT PSB is currently considering the quantification of environmental externalities in greater detail. The analysis tool will be changed to reflect any new findings. The analysis tool has the capability of calculating avoided cost benefits using specific environmental impacts for each fuel.

   The avoided cost benefits are based on savings which occur over a thirty year period. It is assumed that replacement electric water heater(s) would have an efficiency similar to electric resistance models. No adjustments to savings have been made in light of the proposed DOE rulemaking which would require significantly higher efficiencies for electric water heaters. The analysis tool can be modified to account for these impacts as necessary.

References

"Demand Side Management Program Description, Cost-Effective Screening Results, ENPRO Modelling Results, and Monitoring and Evaluation Plan," filed May 1991 with the Vermont Public Service Board in Docket # 5270 -WEC-1.

Gamble, J. F. and Weedall, M. J. 1992. "The Politics of Fuel Switching: A Vermont Case Study." Integrated Resource Planning - *Proceedings from the ACEEE 1992 Summer Study on Energy Efficiency in Buildings*, Volume 8, pp. 8.59-8.65. American Council for an Energy-Efficient Economy, Washington, D.C.

Hamilton, L. B., Milford, L., Parker, S. and Steinhurst, W. 1992. "Fuel Switching Programs in Vermont: Issues and Experiences." Integrated Resource Planning - *Proceedings from the ACEEE 1992 Summer Study on Energy Efficiency in Buildings*, Volume 8, pp. 8.79-8.87. American Council for an Energy-Efficient Economy, Washington, D.C.

Raab, J. and Cowart, R. 1992. "Fuel Switching in Vermont: Pragmatic Answers to Ideological Issues." *Proceedings of the Fourth National Conference on Integrated Resource Planning.* Washington, D.C.

"WEC Technical Support Document for DSM Resource Planning," filed May 1991 with the Vermont Public Service Board in Docket # 5270-WEC-1.

Witte, P., Wilder, M., and Kushler, M. 1994. "Evaluating Low-Income Water Heater Fuel Switching." *Home Energy*, March/April, Volume 11, Number 2, pp. 29-31.