ANALYSIS OF MINIMUM EFFICIENCY STANDARDS AND REBATE INCENTIVE PROGRAMS FOR DOMESTIC REFRIGERATORS IN THE PACIFIC NORTHWEST

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ABSTRACT

This paper examines the energy savings potential and cost-effectiveness of stimulating higher levels of refrigerator efficiency in the Pacific Northwest through minimum efficiency standards and rebate incentive programs. It is estimated that refrigerator efficiency standards could save 27-32 MW(avg) by 1995 in the region. Rebate programs offered by BPA could save 5-7 MW(avg) by the same year. There is much greater savings potential with standards because they would apply to the entire region as opposed to the service territory available to BPA for conservation programs, and because standards affect all product sales while rebate programs have a limited response. Furthermore, refrigerator standards are much easier to implement and administer in comparison to rebate programs, they are cost-effective for consumers in the Northwest, and they require virtually no expenditure on the part of utilities or states. If minimum efficiency standards are adopted, it may still be worthwhile to offer rebates as an incentive for the purchase of highly-efficient models.

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BACKGROUND

Refrigerator-freezers (R/Fs) and freezers (FRs) account for about 10% of the total energy consumed and 16% of electricity consumed in the residential sector in the Bonneville Power Administration (BPA) forecast region (Oregon, Washington, Idaho and Western Montana) [1]. After space and water heating, refrigerators are the most important electrical end-use.

Much progress has been made in improving the energy performance of R/Fs and FRs in recent years. The typical top mount, automatic defrosting R/F model sold in 1972 consumed close to 2000 kWh/yr, the typical model sold in 1983 consumed about 1200 kWh/yr, and the top-rated mass-produced model now manufactured consumes just 750 kWh/yr [2]. If every household in the region had the best R/F model now produced, the electricity savings would be about 5 billion kWh/yr, approximately the power supplied by 1000 MW of nuclear or coal-fired generating capacity.

A survey of nearly 1500 refrigerator and freezer models displayed in 56 appliance stores in Boise, Portland, and Seattle was conducted by BPA in December, 1985 [3]. The average electricity consumption of top-mount, automatic defrost refrigerators observed in the survey was 1070 kWh/yr, close to the national average based on extrapolating trends in efficiency improvement from recent years.

Although energy-efficient R/Fs and FRs tend to cost slightly more than models of average efficiency, the extra first cost is paid back within a few years through reduced operating costs [4]. This is true even with the relatively low electricity prices in the Northwest [5].

But energy-efficient R/Fs and FRs are not widely purchased by consumers, and the major manufacturers aren't offering models with efficiencies close to the life-cycle cost minimum. Studies of the life-cycle costs associated with R/Fs and FRs show a minimum life-cycle cost at twice the average efficiency of new models produced in 1984 [6].

There are a number of reasons for this "market failure" [4]. First, consumers tend not to pay attention to the efficiency of appliances or consider "life-cycle" cost when shopping. Although the yellow Energy Guide labels displayed in stores provide energy consumption information, studies have shown that non-energy factors such as brand name, appearance, and dealer recommendation have a greater effect on purchasers. Second, replacement purchases are often made in a hurry when an old model breaks down. Third, a substantial number of purchases are made by builders and landlords, "third-parties" who usually do not pay the operating costs and have little incentive to buy an efficient model. Last but not least, manufacturers are not willing to introduce efficiency measures unless they pay for themselves in operating cost savings in about three years or less.

The Northwest Power Planning Council recognizes the savings potential from efficient R/Fs and FRs as well as the barriers to their production and sale. In the 1983 regional power plan, they directed BPA to develop and implement incentive programs for efficient appliances [7]. The Council also called for the evaluation of minimum efficiency standards for appliances sold in the region.

In response to this directive, the Office of Conservation at BPA funded the evaluation of both rebate incentive programs and minimum efficiency standards for R/Fs and FRs [5,8]. While both rebates and standards have been implemented and evaluated in various parts of the country, they have not been directly compared in other studies. Energy savings potential and economic feasibility are the primary issues considered in the study summarized here.

MINIMUM EFFICIENCY STANDARDS

The analysis of the potential electricity savings and cost effectiveness of adopting minimum efficiency standards in the Pacific Northwest applies to both R/Fs and FRs. The standards levels considered are those adopted by the California Energy Commission in Dec., 1984 [9]. The new standards are scheduled to go into effect in California in 1987 and 1992. The California standards levels are considered for consistency and for ease of analysis. Also, these standards have been formally proposed and considered by states in the Northwest.

Two cases are developed regarding future progress in new product efficiency in the absence of explicit standards in the BPA region (see Table I for data on R/Fs). The two cases are meant to provide upper and lower bounds on the savings that would result from standards. The first case is based on forecasts by the appliance industry of the average electricity consumption of new R/F and FR models in the future in an unregulated marketplace. In the second case, further efficiency improvements are assumed in the unregulated marketplace due to the "spillover effect" from having standards in California.

The two cases specify average reductions in the electricity use of new models of 1.9%/yr and 3.6%/yr during 1986-2004. For comparison, during the period 1978-1984 while standards were in effect in California (but no other states), the average reduction in the electricity use of refrigerators sold nationwide was 4.0%/yr [2].

Table I also shows the assumed average electricity consumption levels with standards in effect and the unit savings in each case. It is assumed that the average electricity use of new models is equal to the standards levels the years standards go into effect, but that electricity use drops steadily thereafter (Table I, column C). Regarding unit savings, it is assumed in the first case that adopting R/F standards leads to an average reduction in new model electricity consumption of 208 KWh/yr by 1992 and remains constant in the period 1992-2004. In the second case, unit savings increases to 180 KWh/yr by 1992 but steadily declines thereafter as the unregulated marketplace "catches up" with the rapid efficiency improvements brought about by standards. Similar assumptions are made for FRs.

In calculating aggregate savings for the entire region, the analysis is carried out on the basis of both gross and net savings. Gross savings account for just direct electricity use by R/Fs and FRs, while net savings take into account impacts on electricity consumption for space conditioning. Space heating requirements increase and space cooling requirements decrease if R/F or FR efficiency is improved because of the reduction in appliance waste heat. The savings reduction in proceeding from gross to net savings is 25-37% depending on the type of utility and the year of analysis [10].

The results show that by adopting standards in the entire BPA region, there would be a cumulative savings of 35-59 MW(avg) by 1995 and 55-147 MW(avg) by 2004. [Note: A MW(avg) is a MW used continuously or 8760 MWh per year.] The savings are greater when ignoring the potential "spillover effect" from California and the impacts on space conditioning. Even in the worst case analyzed, the value of the overall cumulative electricity savings to consumers by 2004 is $206 million (in constant 1985 dollars).

Figure 1 shows the potential savings from R/F standards by 1995. When net savings are considered, the savings potential is in the range of 27-32 MW, with greater savings in case I than in case II (in the latter, it is assumed that there is spillover from standards in California in the absence of standards in the Northwest). About 60% of the savings are from customers of private utilities and 40% from public utilities.

A sensitivity analysis was performed assuming that the average electricity consumption of R/F and FR shipments in 1987 and 1992 is 10% below the standard level [8]. This is in contrast to zero "undershoot" assumed in the original analysis. With this change, the estimated savings are 50-75% greater than in the original analysis. The high variation is a consequence of estimating savings by taking the difference between relatively similar electricity consumption values (see Table I).

The cost-effectiveness of the standards is evaluated by examining the cost of saved energy (CSE) and the life cycle cost (LCC) to consumers from buying models of varying efficiency. Cost-efficiency curves developed by the Northwest Power Planning Council are used [11]. Also, a consumer discount rate of 6% above inflation is assumed. This rate is based on the opportunity cost for consumers considering the range of alternative investment options.

The analysis shows that in virtually all cases, models that significantly exceed the efficiency levels called for in the proposed standards are cost-effective for consumers even with the relatively low electricity prices in the Northwest [5]. Table II shows the cost of saved energy results for two-door R/Fs with automatic defrost. In this case, reducing electricity use to 613 kWh/yr is associated with an incremental CSE that is below 40 mills/kWh when savings are evaluated on either a gross or net basis.

REBATE INCENTIVES

Because of its complexity, the rebate program analysis is performed only for R/Fs. Rebate and qualification levels are first proposed for programs targeted at different market segments (i.e., builders, landlords and consumers). The economic feasibility of more efficient models and rebates is then evaluated from the perspective of both consumers and BPA. For a complete discussion of the analysis of consumer benefits and other issues, see the original report [5].

Rebate and qualification levels are set and savings estimated based on 1985 R/F product offerings [5]. It is assumed that models normally bought by "third-parties" (builders and landlords) are less efficient than those bought by consumers since the former generally do not pay the operating cost, and thus have no incentive for buying a slightly more costly, energy-efficient model.

A "two-tier" rebate program consisting of two qualification and rebate levels is proposed for most product categories. The higher qualification level (in terms of KWH/yr rating) allows 35-50% of the models offered to qualify for rebates while the lower, more restrictive level limits rebates to 10-20% of the models offered. The two-tier scheme is a compromise between a single rebate level and continuously varying rebates. Two qualification and rebate levels have been used in refrigerator rebate programs offered by Pacific Gas and Electric Co. and Northern States Power Co.

The rebate levels are generally set so that the overall cost to BPA (rebates plus administration) is equal to or below the estimated value of the resulting electricity savings. Electricity savings are valued on the basis of BPA's projected marginal power costs for 1986-2005. These marginal costs begin at 19 mills/kWh in 1985 and rise to 35 mills/kWh by 2005 (in 1985 dollars) [12].

For top-mount R/Fs, the proposed rebate levels are in the range of $10-25 for consumer purchasers and $10-40 for third party purchasers depending on the product class. For side-by-side R/Fs, the proposed rebate levels are $35-50 for consumer purchasers and $50-75 for third parties. In most cases, the proposed rebate payments are greater than the anticipated extra first cost for qualifying models according to engineering analysis. However, manufacturers may add a first cost premium to more efficient models that exceeds these rebate amounts.

Additional analysis of R/F rebates for third-party purchasers was conducted because this market is most in need of financial incentives [8]. In this case, rebate payments of $15-25 are proposed for builders and landlords who purchase the 15% most efficient models. Rebates of this magnitude should be sufficient to influence a substantial number of third-party purchasers because they buy in bulk at discounted prices. As Table III shows, such rebates are very cost-effective for BPA. It is estimated that a rebate program only for third-party purchasers would cost BPA approximately $240,000-415,000 per year.

The market segmentation and savings potential analysis applies to the territory thought to be eligible for BPA's incentive programs (all public utility customers and 47% of private utility customers in the BPA region). The analysis shows that consumers are expected to buy about 73% of the R/Fs sold in this area in the near-term (1986-95). Landlords for single family housing (1-4 units) are estimated to account for 10% of sales, landlords for multi-family housing 7%, site-built home builders 7%, and mobile home builders 3% of sales. Consequently, BPA would need to offer incentive programs to consumer purchasers if it wants to reach most of the potential market.

Overall electricity savings potential is estimated assuming two levels of response. The high response case assumes 50% of sales to third party purchasers and 30% of sales to consumers qualify for rebates. The low case assumes 30% and 20% response levels in the two market segments. The high response case shows an overall savings potential of about 700 KW(avg) per year in all market segments in the period 1986-95. In the low response case, the overall potential is about 460 KW(avg) per year. These estimates are based on a 33% reduction in gross savings to account for greater electricity use for space heating as a result of increasing R/F efficiency.

Figure 2 shows the aggregate savings results. If full-scale rebate programs are offered beginning in 1986, the total cumulative savings potential in all markets is 7.1 MW by 1995 in the high response case and 4.6 MW in the low response case. About 65% of the savings are from consumer purchases, 22% from landlord purchases, and 13% from builder purchases. It is estimated that a full-scale rebate program would cost BPA $2.2-2.6 million per year in the high response case and $1.4-1.6 million per year in the low response case.

It is important to acknowledge that it was necessary to make many assumptions in the course of the rebate program analysis. Actual pilot programs are needed to better understand cost, response, and savings.

COMPARISON OF STANDARDS AND REBATES

The estimated savings potential by 1995 from minimum efficiency standards for R/Fs is 27-32 MW, compared to about 5-7 MW of savings from a comprehensive R/F rebate program. There is much greater savings potential with standards because standards would apply to the entire region and affect all product sales while rebate programs have a limited target population and response. Of course, all or most all utilities could offer rebates by "signing on" to a program sponsored by BPA or by operating their own programs.

Minimum efficiency standards have other advantages compared to rebates. Standards, once adopted, are much easier to implement and administer than rebate programs. Furthermore, standards require virtually no expenditures on the part of utilities and governmental organizations. Some monitoring of retail establishments and enforcement is necessary, but experience in California has shown that compliance to minimum efficiency standards is very high [13].

If standards are adopted for part or all of the region through federal or state action, it may still be useful to offer rebates (as has been done in California) if there is a need for further electricity conservation. Rebate programs should be reanalyzed given the range of product offerings available when standards go into effect. Rebates are more likely to be feasible and result in substantial additional savings if there continues to be wide differences in efficiency within individual categories of R/Fs. Offering rebates also provides an incentive for further efficiency improvements on the part of manufacturers.

In the absence of standards, rebates and promotion may be the most effective strategies available to BPA and utilities in the region for encouraging higher levels of appliance efficiency. Pilot programs including experiments with different program designs are necessary in order to more accurately assess purchaser response and the benefits of offering the modest rebates discussed above. Pilot programs will be most useful if they include a quantitative evaluation where information on purchases and product efficiencies are collected from both those eligible for participation and a control group.

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Table I - Assumptions Regarding the Electricity Consumption of New Refrigerators over Time in the Pacific Northwest

	Average Electricity Consumption or Savings (KWh/yr)				
Year	(A)	(B)	(C)	(D)	(E)
1986	1060	1060	1042	18	18
1987	1026	1026	991	35	35
1988	998	998	934	64	64
1989	970	970	877	93	93
1990	942	942	820	122	122
1991	928	914	763	165	151
1992	914	886	706	208	180
1993	900	858	692	208	166
1994	886	830	678	208	152
1995	872	802	664	208	138
1996	858	774	650	208	124
1997	844	746	636	208	110
1998	830	718	622	208	96
1999	816	690	608	208	82
2000	802	662	594	208	68
2001	788	634	580	208	54
2002	774	606	566	208	40
2003	760	578	552	208	26
2004	746	550	538	208	12

(A) Case I electricity consumption in the marketplace without appliance standards in the Northwest assuming efficiency improvements as forecasted by AHAM.

(B) Case II electricity consumption in marketplace without appliance standards in the Northwest assuming further efficiency improvements over the long run due to "spillover" from standards in California.

(C) Electricity consumption with California's appliance standards adopted by Pacific Northwest states.

(D) Average savings with standards, Case I (columns A minus C).

(E) Average savings with standards, Case II (columns B minus C).

Table II - Cost-effectiveness of Refrigerator Energy Efficiency Measures Based on the NWPPC Conservation Supply Assumptions (a)

Measure	Elect. Use (KWh/yr)	Gross Savings (KWh/yr)	Measure Cost (1985 $)	Cost of Saved Energy (mills/KWh) Gross (b)	Net (c)
Base	1354	--	--	--	--
Design opt 1	1208	146	7.38	4.2	9.3
Design opt 3	1072	136	7.44	4.5	10.1
Design opt 5	978	94	8.17	7.2	16.0
Design opt 2	940	38	3.72	8.1	18.1
NRDC insulation	768	172	14.82	7.2	15.9
High eff fan	688	80	10.98	11.4	25.3
Optimal insulation	613	75	13.18	14.6	32.4
EER = 4.5	518	95	27.45	24.0	53.3
Evacuated panels	228	290	88.40	25.3	56.2
EER = 4.8	217	11	5.49	41.4	92.1
Double FR gasket	204	13	20.60	131.5	292.3
Double door gasket	186	18	34.04	157.0	348.8

(a) Assuming a 17 cubic foot top mount refrigerator-freezer with a 22 year lifetime.

(b) Cost of saved energy based on gross savings assuming a 6% real discount rate.

(c) Cost of saved energy based on net savings assuming a 55% reduction from gross savings and a 6% discount rate.

Table III - Cost-effectiveness of Offering Rebates to the Third-party Market - Alternative Assumptions

Product category (a)	Rebate amount ($)	Avg. gross savings (kWh/yr)	Cost-effectiveness for BPA (b)	
			NPV ($)	BCR
SD-MD 10.5-12.4 CF	15	120	18.1	1.95
SD-MD 12.5-14.4 CF	15	35	-8.2	0.57
TM-PAD 10.5-12.4 CF	15	95	10.4	1.55
TM-PAD 12.5-14.4 CF	15	75	4.2	1.22
TM-AD 12.5-14.4 CF	25	170	23.60	1.81
TM-AD 14.5-16.4 CF	25	150	17.40	1.60
TM-AD 16.5-18.4 CF	25	100	1.90	1.07
TM-AD 18.5-20.4 CF	25	110	5.00	1.17
TM-AD 20.5-24.4 CF	25	170	23.60	1.81

(a) SD - single door; MD - manual defrost; TM - top mount; PAD - partial automatic defrost; AD - automatic defrost; CF - cubic feet.

(b) NPV - net present value of benefits minus costs; BCR - benefit-cost ratio.

Figure 1

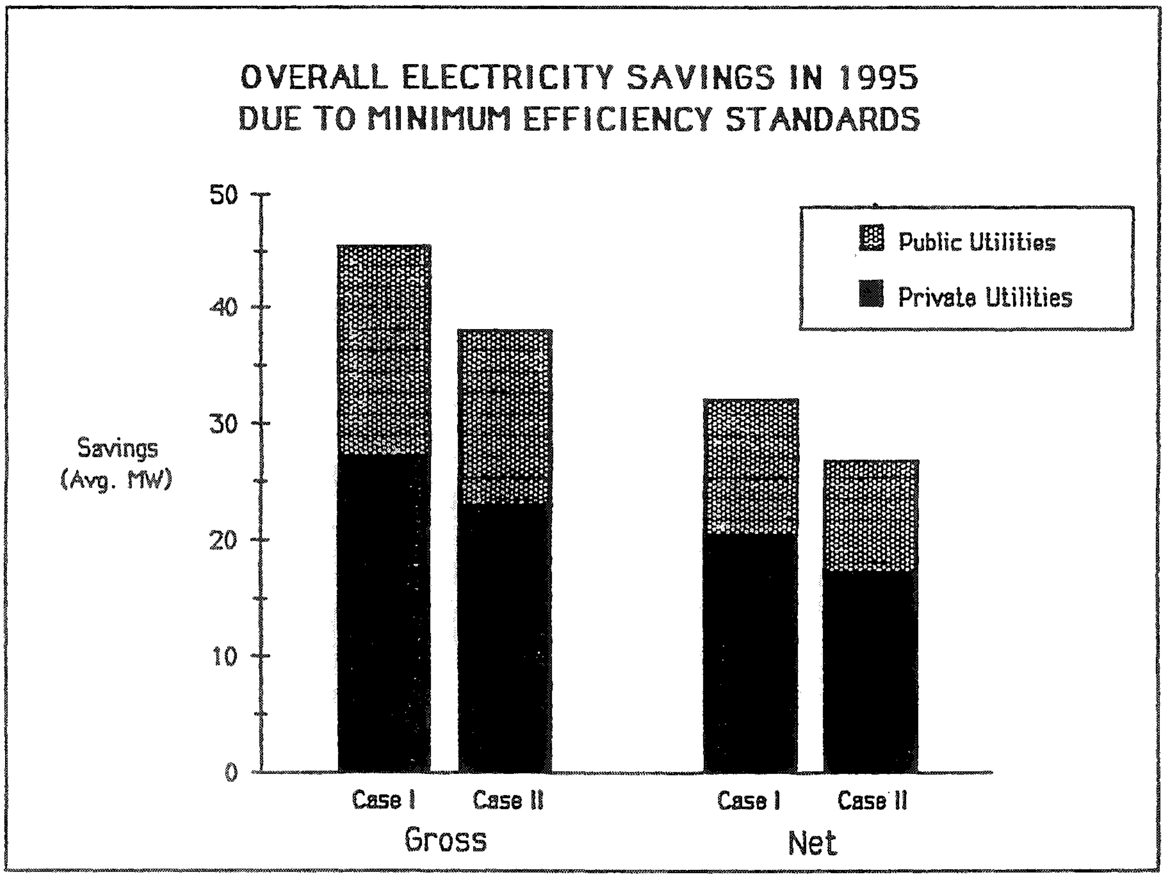
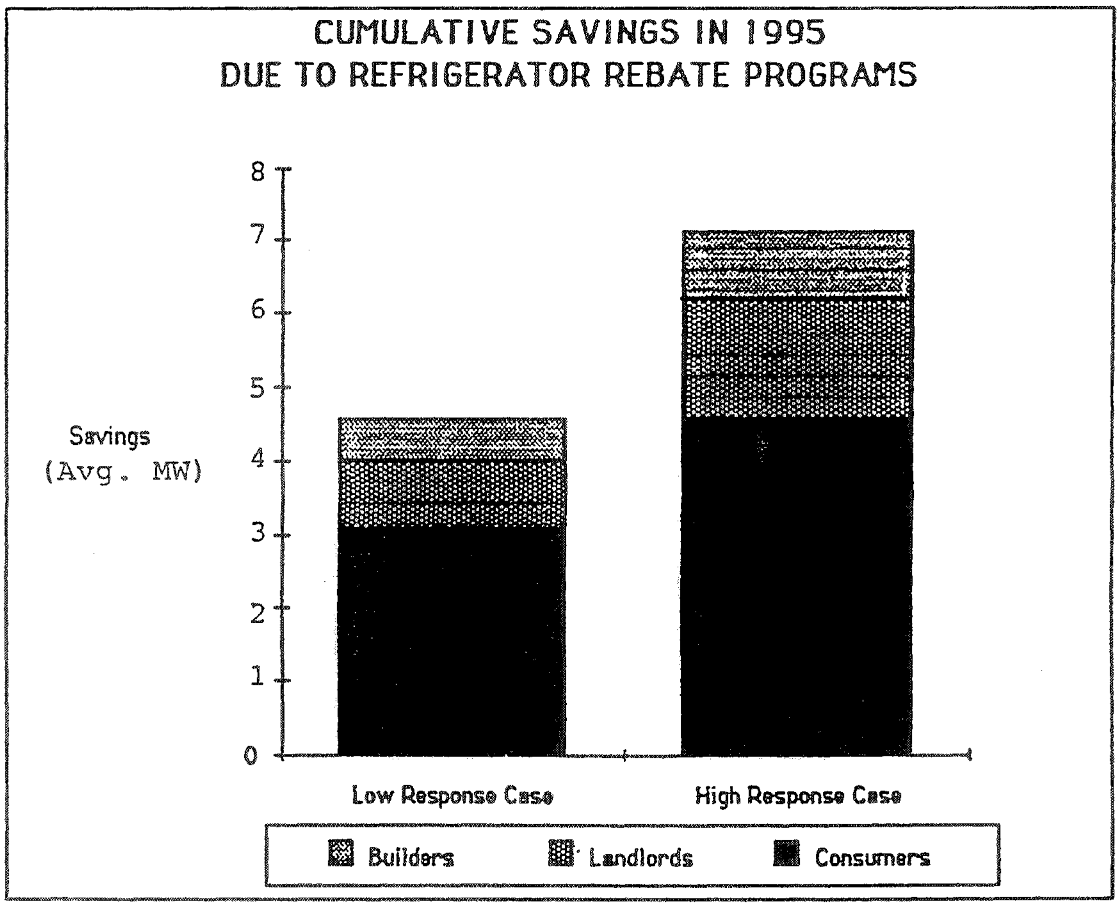

OVERALL ELECTRICITY SAVINGS IN 1995
DUE TO MINIMUM EFFICIENCY STANDARDS
Public Utilities
Private Utilities
Savings
(Avg. MW)
50
40
30
20
10
0
Case I
Case II
Gross
Case I
Case II
Net

Figure 2


CUMULATIVE SAVINGS IN 1995
DUE TO REFRIGERATOR REBATE PROGRAMS
Savings
(Avg. MW)
8
7
6
5
4
3
2
1
0
Low Response Case
High Response Case
Builders
Landlords
Consumers