Optimizing DSM Program Portfolios

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Abstract

One of the most fundamental questions in DSM program design and evaluation is whether the mix of programs in the DSM portfolio is the best or optimal set of programs for that jurisdiction. Could another mix of programs produce the same amount of savings with reduced uncertainty? Or, would it be possible to generate substantially more savings with little increase in the amount of uncertainty in the savings?

This paper addresses the issue of optimizing DSM program portfolios by applying theories from the financial community, namely the modern portfolio theory (MPT), used to create efficient stock portfolios. Like stock portfolios, energy efficiency program portfolios should be trying to provide as much return for the investment with as little risk as possible within the regulatory constraints. For energy efficiency programs, the return they are providing is actual energy savings and the risk is the uncertainty that these savings will be achieved.

Using the MPT, investors are able to create an "efficient portfolio," a portfolio that has the smallest attainable portfolio risk for a given level of expected return (or the largest expected return for a given level of risk). For every set of stocks or DSM programs, a curve known as the Efficient Frontier, can be calculated to show the relationship between risk and return for an optimized portfolio. If the portfolio lies below the curve then the portfolio is not efficient; the same return could be achieved with lower risk. The goal is to design a stock portfolio or an energy efficiency program portfolio that optimizes the return (or overall savings) and minimizes the risk (uncertainty that the savings will be achieved).

The paper applies the MPT to two of the most successful DSM program portfolios in the U.S. to determine if these portfolios could be improved. The analysis uses historical program data to develop the expected savings for each program, the uncertainty of the expected savings and the correlation of the program savings with the other programs in the portfolio. The results of the analysis are plotted against the Efficient Frontier to determine if the current portfolios of programs are the best or optimal set of programs. The analysis indicates that increased savings can be achieved without increasing the uncertainty of the savings.

The authors show that MPT can be used to evaluate the optimal mix of programs and is a valuable tool in DSM portfolio design. In designing programs, DSM program developers and regulators often have to balance many constraints including market transformation goals, low-income spending, etc. Using the MPT, some of these program constraints may actually help to balance the overall portfolio of programs, demonstrating added value, not constraint, to the portfolio.

Introduction

One of the most fundamental questions in DSM program design and evaluation is whether the mix of programs in the DSM portfolio is the best or optimal set of programs for that jurisdiction. Could another mix of programs produce the same amount of savings with reduced uncertainty? Or, would it be possible to generate substantially more savings with little increase in the amount of uncertainty in the savings?

This paper will address the issue of optimizing DSM program portfolios by applying theories from the financial community, namely the modern portfolio theory (MPT) used to create efficient stock portfolios. Like stock portfolios, energy efficiency program portfolios are trying to provide as much return for the investment with as little risk as possible. For energy efficiency programs the return they are providing is actual energy savings and the risk is the uncertainty that these savings will be achieved.

The paper will apply the MPT to the portfolio of programs in the New Jersey Clean Energy Programs (NJCEP) and the portfolio of programs managed by Efficiency Vermont to determine if these portfolios could be improved. The analysis will use historical program data to develop the expected savings for each program, the uncertainty of the expected savings, and the correlation of the program savings with the other programs in the portfolio. The results of the analysis will be plotted against the Efficient Frontier to determine if the current portfolios of programs are the best or optimal set of programs. The analysis may also show that increased savings can be achieved without increasing the uncertainty of the savings.

Modern Portfolio Theory

Modern Portfolio Theory, unlike traditional asset management, which focuses on predicting individual stock price movements using fundamental or technical analysis, looks at the performance of a portfolio of assets based on the combination of its components' risk and return.

One of the fundamentals of a successful portfolio, be it stocks or energy efficiency programs, is diversification. Diversification helps spread risk between stocks, currencies and markets. It provides investors with a means of hedging investments against geo-political events (such as war or oil shortages) and unexpected market events (stock market crashes or natural disasters). Through diversification, the risk of a portfolio can be reduced. Modern portfolio analysis has shown that even a random mix of investments is less risky than putting all your money in a single stock. In other words, for the same amount of risk, diversification can increase returns.

The financial economics and probability and statistical theory that support the modern portfolio theory are complex and beyond the scope of this discussion. However, an example can help demonstrate this relationship. Consider a portfolio that contains two energy efficiency programs: one that saves energy during a cold winter and another that saves energy if the winter is particularly mild. If a utility only invested in one of these programs the energy savings would be greatly dependent on the winter weather. There would be uncertainty or risk associated with the expected savings of the programs. However. if the utility invested in both of these programs. there would be less uncertainty or risk associated with the overall energy savings because the combination of the programs will save energy no matter what the winter weather. The crucial insight of modern portfolio theory is that the risk of an individual asset is of little importance to the investor; the importance lies in is its contribution to the portfolio's risk as a whole.

Like stock portfolios, energy efficiency program portfolios are trying to provide as much return for the investment with as little risk as possible. For energy efficiency programs, the return they are providing is actual energy savings and the risk is the uncertainty that these savings will be achieved.

If all the possible combinations of investment strategies for the given assets are examined,is apparent that each portfolio had a specific mean return and standard deviation of return associated with it. Plotting the means on one axis and the standard deviations on another axis, you can create a graph like in Figure 1.

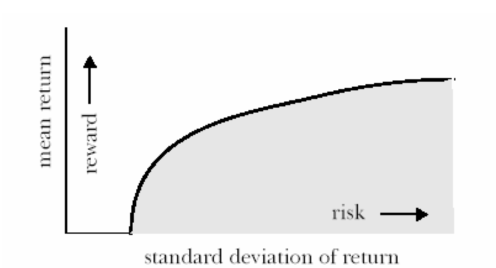

Figure 1. Return versus Risk Graph

Points on or under the curve represent possible combinations of investments. Points above the curve are unobtainable combinations given the particular set of assets available. For any given mean return, there is one portfolio that has the smallest standard deviation (risk) possible. This portfolio lies on the curve at the point that intersects the mean of return (Figure 2).

Similarly, for any given standard deviation of return (risk), there is one portfolio that has the highest mean return obtainable (Figure 3). This portfolio lies on the curve at the point that intersects the standard deviation of return.

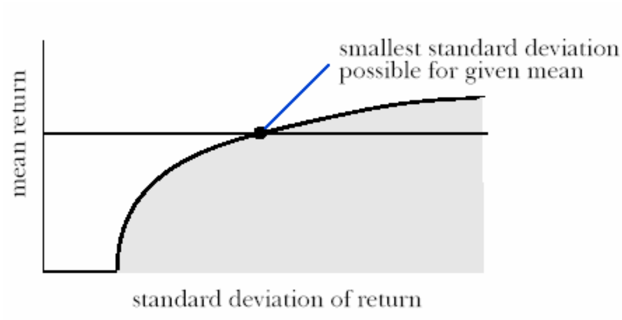

Figure 2. Minimum Risk for Given Return

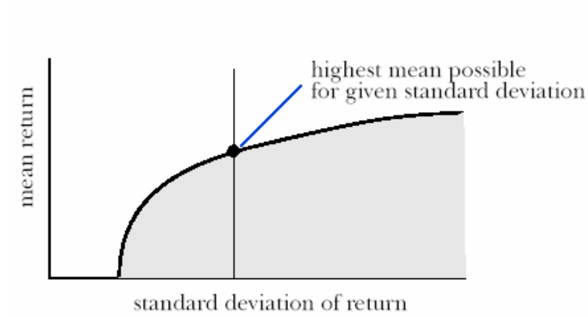

Figure 3. Maximum Return for Given Risk

Portfolios that lie directly on the curve are called efficient, since it is impossible to obtain higher mean returns without generating higher standard deviations, or lower standard deviations without generating lower mean returns (Markowitz). The curve of efficient portfolios is often called the efficient frontier. Portfolios that lie below the curve are called inefficient, meaning better portfolios exist with either higher returns, lower standard deviations, or both. The curve in Figure 4 shows the relationship between risk and return for an optimized portfolio. The goal is to design a stock portfolio or an energy efficiency program portfolio that optimizes the return (or overall savings) and minimizes the risk (uncertainty that the savings will be achieved).

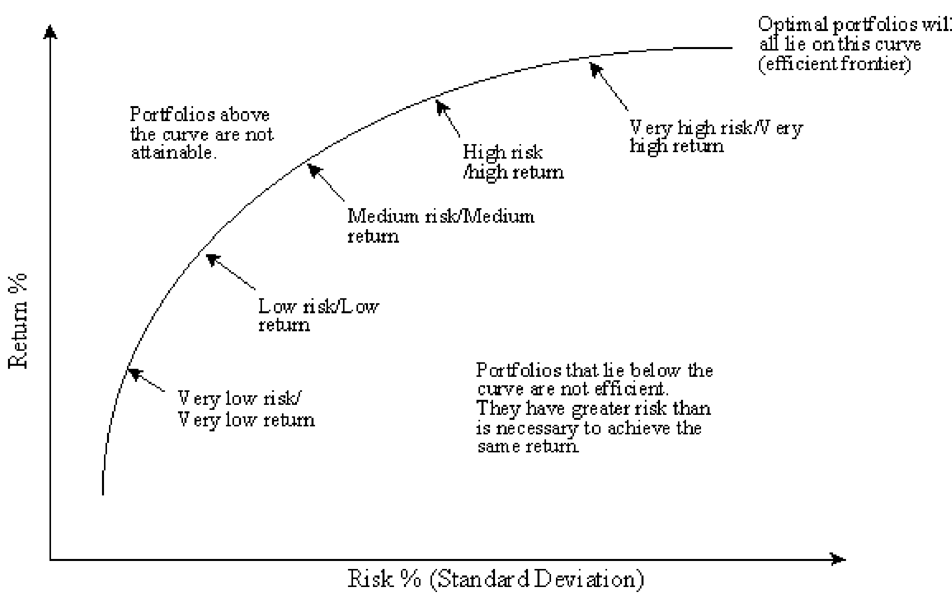

Figure 4. Efficient Frontier

To add to the complexity of the portfolio, most stocks, and arguably energy efficiency programs, are correlated to some extent. The correlation between two stocks indicates how closely they move together. A positive correlation means that the stock values move in the same direction. A negative correlation means that the stock values move in the opposite direction. As with stocks, two energy efficiency programs can be correlated. For example, you would expect a strong correlation between energy efficiency programs in the same sector.

Optimizing the New Jersey Clean Energy Program Portfolio

The modern portfolio theory was applied to the NJCEP Portfolio to determine if the current portfolio is efficient, in terms of maximizing the return (Savings/Spending) while minimizing the risk (uncertainty). First, the annual return for each program was calculated for 2001- 2005. The annual return was defined as the lifetime savings achieved per actual spending during that program year. The lifetime energy savings included the natural gas savings converted to kWh equivalent (kWh_e). Table 1 presents the annual returns of the New Jersey programs.

Table 1. NJCEP Lifetime Savings per Actual Annual Program Expenditures

	Lifetime Savings per Expenditures (Lifetime kWh_e/$)				
Program	**2001**	**2002**	**2003**	**2004**	**2005**
Commercial/Industrial Construction	52.22	60.41	110.86	111.33	132.21
ENERGY STAR Products	86.60	-	59.21	95.15	90.07
NJ ENERGY STAR Homes	0.28	50.75	58.44	53.73	65.64
Residential HVAC	55.01	58.50	59.27	60.72	72.87
Residential Low Income	66.22	38.75	31.30	32.69	24.19
Total Lifetime Savings per Expenditures	**42.53**	**52.92**	**72.79**	**72.48**	**80.92**

By examining the savings performance for each of the programs over this five year period, the average performance and variance in the performance of each of the programs was calculated. The programs have been evolving over the past five years and the current programs are much different than the programs were in 2001. To account for this change in the programs, weightings or probabilities were assigned to each year to indicate the likeliness that that year's performance would be representative of the program's performance in 2006. Table 2 shows the assigned probabilities for each program and each year. This table also shows the expected return (or weighted average of the performance) and the uncertainty (standard deviation) for each of the programs.

In addition the data in Table 2 was used to calculate the correlation and the co-variance between the programs in this portfolio. The relationship of the performance of the programs relative to each other is an important aspect in developing an efficient portfolio.

Table 2. NJCEP Lifetimes Savings per Expenditures – Expected Values and Uncertainty (Lifetime kWh_e/$)

Year	**Probability of Predicting 2006 Performance[1]**	**C&I**	**ES Products**	**NJESH**	**Res. HVAC**	**Res. LI**
2001	**5%**	52.22	86.60	0.28	55.01	66.22

[1] More recent years are likely to better predict the performance in the current year than earlier years would.

2002	**5%**	60.41	-	50.75	58.50	38.75
2003	**20%**	110.86	59.21	58.44	59.27	31.30
2004	**25%**	111.33	95.15	53.73	60.72	32.69
2005	**45%**	132.21	90.07	65.64	72.87	24.19
Expected Return		115.13	80.49	57.21	65.50	30.57
Uncertainty (Std Dev)		35.06	39.54	26.04	6.82	16.27

Table 3 presents the annual program spending from 2001 through 2005. The 2005 percent spending by program was used as to calculate the expected return and the risk associated with the current portfolio.

Table 3. NJCEP Actual Annual Program Expenditures ($000s)

Program	**2001**	**2002**	**2003**	**2004**	**2005**	**2005** Distribution
Commercial/Industrial Construction	$12,346	$38,271	$30,555	$29,661	$24,437	30%
ENERGY STAR Products	$2,493	$2,803	$6,305	$8,449	$5,973	7%
NJ ENERGY STAR Homes	$15,758	$10,945	$15,365	$21,736	$23,261	28%
Residential HVAC	$15,823	$18,490	$14,444	$15,564	$13,117	16%
Residential Low Income	$10,354	$13,268	$15,435	$14,266	$15,467	19%
Total Annual Expenditures	**$56,929**	**$84,346**	**$82,398**	**$92,233**	**$85,329**	**100%**

Optimization algorithms were used to determine the most efficient distribution of spending among the programs at different levels of risk and return. Table 4 shows the comparison of the several portfolios examined. As Figure 5 shows, although the current mix of program spending is below the efficient frontier, it is quite close to the frontier. The spending allocation of the current portfolio could be adjusted to provide the same return with less risk. By reallocating program spending to 49% C&I and 51% Residential and Low Income, the risk can be reduced from 103 to 48, or 53%. Likewise, if the current risk level is acceptable, the return can be increased from 72.42 to 81.81 $kWh_e/\$$, or 13%, by reallocating the spending 61% to C&I and 39% to Residential Low Income.

Table 4. NJCEP Comparison of Portfolios

			% of Portfolio Spending				
Portfolio	**Risk (Uncertainty)**	**Return**	**C&I**	**ES Products**	**NJESH**	**Res. HVAC**	**Res. LI**
Current	103.03	72.42	30%	7%	28%	16%	19%
Current - Min Risk	48.05	72.42	49%	0%	0%	0%	51%
Current - Max Return	103.03	81.811	61%	0%	0%	0%	39%
Portfolio A	7.05	57.183	24%	0%	4%	15%	57%
Portfolio B	30.05	67.945	44%	0%	0%	0%	56%
Portfolio C	303.03	102.231	85%	0%	0%	0%	15%

Figure 5 shows how the current portfolio relates to the efficient frontier portfolios. This figure also shows the relative risk and return of each of the six portfolios analyzed above.

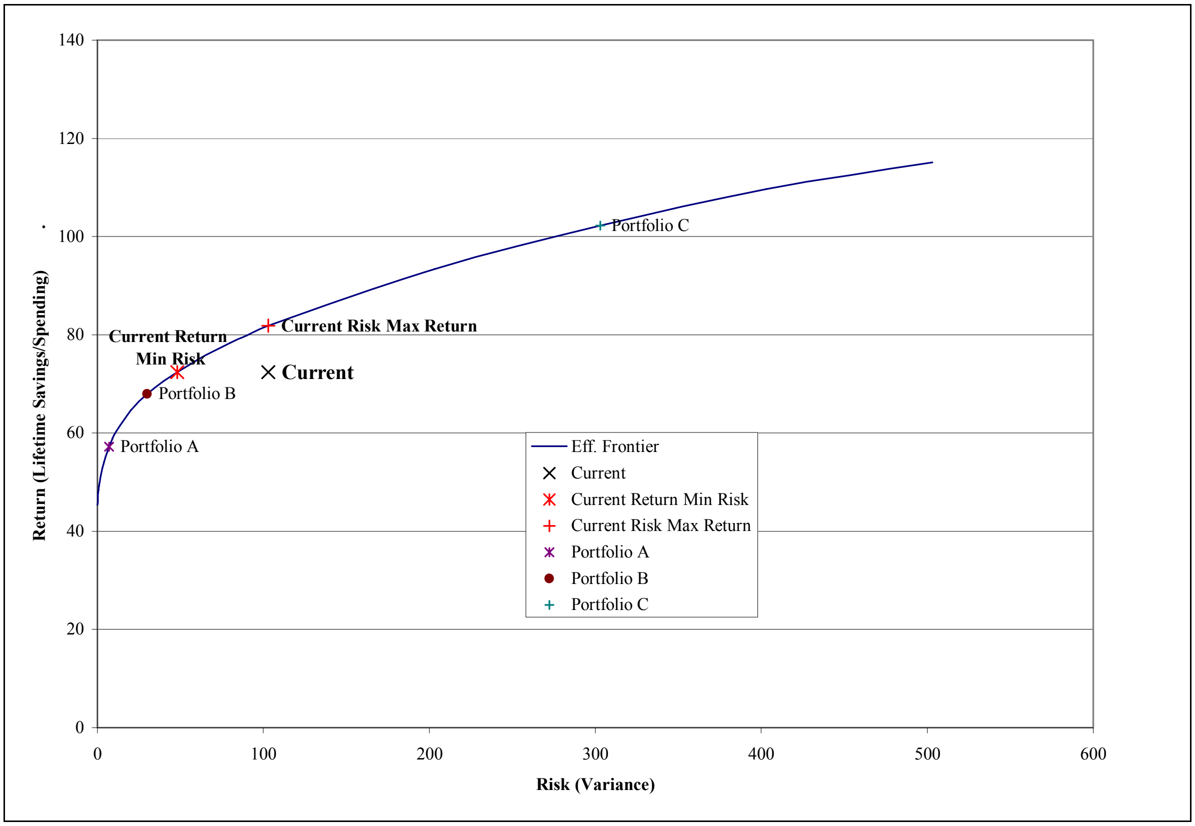

Figure 5. New Jersey Clean Energy Programs Efficient Portfolios

A similar analysis can be done for programs not currently in the portfolio, if historical data is available. For example, if NJ was to consider adding a new industrial program; performance data (savings per spending) of a similar program in a different state could be used to determine the risk and return of that program. This data would be added to the previous analysis and the optimal portfolio could be recalculated.

Optimizing Efficiency Vermont's Program Portfolio

A similar analysis was performed for the Efficiency Vermont portfolio of programs to determine if the current portfolio is efficient, in terms of maximizing the return (Savings/Spending) while minimizing the risk (uncertainty). First, the annual return for each program was calculated for 2000- 2005. The annual return was defined as the lifetime savings achieved per actual spending during that program year. Table 5 presents the annual returns of the Efficiency Vermont programs.

Table 5. EVT Lifetime Savings per Actual Annual Program Expenditures

	Lifetime Savings per Expenditures (Lifetime kWh/$)					
Program	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Business New Construction	82.33	68.40	41.83	63.11	61.73	46.31
Business Existing Facilities	93.27	94.09	73.42	83.82	87.50	70.45
Residential New Construction	25.31	19.52	21.86	9.46	9.94	9.79
Efficient Products	51.88	70.52	66.45	57.72	58.78	73.39
Residential Existing Facilities	21.41	42.48	219.17	42.89	37.78	30.56

Total Lifetime Savings per Expenditures	66.18	66.70	86.32	59.53	58.68	50.92

By examining the savings performance for each of the programs over this six year period, the average performance and variance in the performance of each of the programs was calculated. Like the New Jersey programs, the Efficiency Vermont programs have been evolving over the past six years and the current programs are much different than the programs were in 2000. To account for this change in the programs, weightings or probabilities were assigned to each year to indicate the likeliness that that year's performance would be representative of the program's performance in 2006. Table 6 shows the assigned probabilities for each program and each year. This table also shows the expected return (or weighted average of the performance) and the uncertainty (standard deviation) for each of the programs.

In addition, the data in Table 6 was used to calculate the correlation and the co-variance between the programs in this portfolio. The relationship of the performance of the programs relative to each other is an important aspect in developing an efficient portfolio.

Table 6. EVT Lifetimes Savings per Expenditures – Expected Values and Uncertainty (Lifetime kWh/$)

Year	Probability of Predicting 2006 Performance[2]	Business New Construction	Business Existing Facilities	Residential New Construction	Efficient Products	Residential Existing Facilities
2001	**5%**	82.33	93.27	25.31	51.88	21.41
2001	**5%**	68.40	94.09	19.52	70.52	42.48
2002	**5%**	41.83	73.42	21.86	66.45	219.17
2003	**20%**	63.11	83.82	9.46	57.72	42.89
2004	**25%**	61.73	87.50	9.94	58.78	37.78
2005	**40%**	46.31	70.45	9.79	73.39	30.56
Expected Return		56.21	79.86	11.63	65.04	44.40
Uncertainty (Std Dev)		14.81	9.95	7.09	8.32	75.62

Table 7 presents the annual program spending from 2000 through 2005. The 2005 percent spending by program was used to calculate the expected return and the risk associated with the current portfolio.

Table 7. EVT Actual Annual Program Expenditures ($000s)

Program	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2005** Distribution
Business New Construction	$1,443	$1,954	$2,174	$2,772	$2,679	$2,699	21%
Business Existing Facilities	$1,027	$1,967	$3,327	$3,735	$3,612	$4,054	32%
Residential New Construction	$524	$920	$1,113	$1,220	$1,414	$1,588	13%
Efficient Products	$1,598	$2,028	$1,645	$1,729	$2,201	$1,988	16%
Residential Existing Facilities	$151	$889	$1,837	$2,189	$2,087	$2,263	18%
Total Annual Expenditures	**$4,746**	**$7,759**	**$10,098**	**$11,647**	**$11,995**	**$12,594**	**100%**

Optimization algorithms were used to determine the most efficient distribution of spending among the programs at different levels of risk and return. Table 8 shows the comparison of the several portfolios examined. As Figure 6 shows, although the current mix of program spending is well below the efficient frontier, the spending allocation of the current portfolio could be adjusted to provide the same return with much less risk. By reallocating program spending to 23% Business New Construction, 2% Business Existing

[2] More recent years are likely to better predict the performance in the current year than earlier years would.

Facilities, 35% Residential New Construction, and 40% Efficiency Products, the risk can be reduced from 65 to 6.5, or 1,010%. Likewise, if the current risk level is acceptable the return can be increased from 45 to 79 kWh_e/$, or 76%, by reallocating the spending 96% to Business Existing Facilities and 4% to Efficient Products.

Table 8. EVT Comparison of Portfolios

			% of Portfolio Spending				
Portfolio	**Risk**	**Return**	**Business New Construction**	**Business Existing Facilities**	**Residential New Construction**	**Efficient Products**	**Residential Existing Facilities**
Current	65.26	44.51	30%	7%	28%	16%	19%
Current Return - Min Risk	6.48	44.51	23%	2%	35%	40%	0%
Current Risk - Max Return	65.26	79.317	0%	96%	0%	4%	0%
Portfolio A	4.84	69.14	10%	36%	0%	52%	2%
Portfolio B	14.34	74.77	0%	66%	0%	34%	0%
Portfolio C	124.34	79.86	0%	100%	0%	0%	0%

Figure 6 shows how the current portfolio relates to the efficient frontier portfolios. This figure also shows the relative risk and return of each of the six portfolios analyzed above.

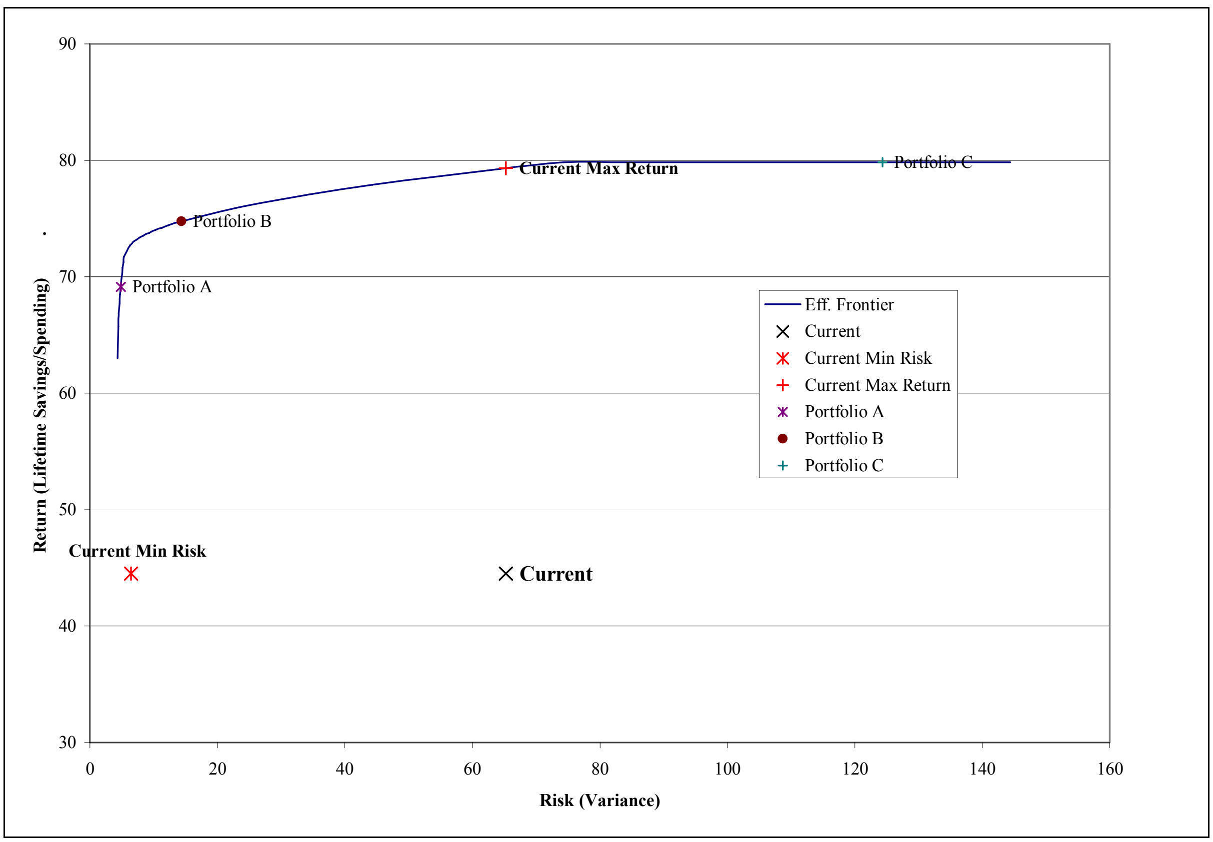

Figure 6. EVT Efficient Portfolios

As mentioned above, a similar analysis can be done for programs not currently in the portfolio if historical data is available. This data would be added to the previous analysis and the optimal portfolio could be recalculated.

Conclusion

Optimizing the savings per dollar spent is not the only goal of energy efficiency programs. For example, some portfolios of programs also have the goal of transforming the markets, which often has a very low savings per actual spending, because the savings continue to occur after the program spending stops. In order to capture these impacts, a more detailed analysis would have to be performed that captures the savings from market transformation programs.

This analysis also doesn't take into account other portfolio constraints, such as minimum spending on low income programs, minimum spending splits between residential and non-residential programs, and geographical equity. These constraints will often drive the mix of programs below the efficient frontier.

This analysis is a first-order approximation of how to optimize an energy efficiency portfolio. The analysis does not adequately take into account many of the regulatory constraints imposed on these program portfolios, e.g. minimum spending on low income programs. This analysis also does not account for the lifetime savings effects of market transformation programs, many of which are residential programs. The actual lifetime savings for market transformation programs would include not only the savings achieved from the measures in the year the program funds were spent, but also the savings achieved from the measures installed in subsequent years due influence of the program. Quantifying the impact savings of these market transformation programs is outside the scope of this paper. However, it is expected that if these market transformation savings were included, the return for the residential programs would increase and the optimized portfolio would have a higher share of residential program spending than was calculated here.

References

Markowitz, H.M. 1991. *Portfolio Selection*. 2nd ed. Cambridge, MA: Blackwell Publishers Ltd.